INSTITUTE FOR SYSTEMS AND ROBOTICS

Annual Report – 2001

Lisbon Pole

♦

Torre Norte, Piso 7
IST, Av. Rovisco Pais
1049 – 001 Lisboa
Portugal

Tel. + 351 21 841 82 89 **Web Server: http://www.isr.ist.utl.pt** **Fax. + 351 21 841 82 91**

Director

Prof. João José dos Santos Sentieiro

Vice - Director

Prof. Maria Isabel Lobato de Faria Ribeiro

Torre Norte, 7º Piso

IST, Av. Rovisco Pais

1049 – 001 Lisboa

Portugal

Tel.: + 351 21 841 82 89

Fax.: + 351 21 841 82 91

e-mail: jjss@isr.ist.utl.pt

Table of Contents

OVERVIEW

Since its foundation, ISR (Lisbon) has given special attention to international cooperation in order to strengthen and broaden its scientific competence. Two types of cooperation are especially noteworthy: firstly, participation in R&D projects in conjunction with universities, research centers, and European businesses of note under the auspices of programs funded by the Portuguese Science and Technology Foundation, European Community and other agencies; and, secondly, training initiatives, primarily through master and doctoral programs. These initiatives have involved not only the Instituto Superior Técnico (IST) and the University of Algarve (UA) but also universities and research centers in Europe and the United States.

In 2001, ISR-Lisbon in partnership with other 3 research units (o Centro de Estudos em Inovaçâo, Tecnologia e Políticas de Desenvolvimento do Instituto Superior Técnico (IN+), o Centro de Recursos Minerais, Mineralogia e Cristalografia (CREMINER) da Universidade de Lisboa e o Centro do IMAR (Instituto do Mar) da Universidade dos Açores) has submitted to the MCT a proposal seeking to be considered an Associate Laboratory, a new status only awarded to research units which have been evaluated as Very Good or Excellent by an international panel of evaluation and whose objectives are considered by the MCT to be of national interest. The proposal was approved and ISR-Lisbon was awarded by the Ministry of Science and Technology the status of Associated Laboratory and has seen his budget to be increased in order to accommodate the possibility of contracting 14 new Ph.D. researchers during the next five years. In this new context the ISR – Lisbon (Associated Laboratory) strategic objectives have been revisited and focused in terms of the following research and development areas:

A – Technologies for Ocean Exploration
B – Monitoring and Surveillance using Robotic Agents
C – Sustainable Technologies and Environment Systems
D – Signal Processing for Communications and Multimedia Networks

In order to push theoretical developments in the fields of marine robotics, underwater acoustics and communications, Computer Vision and Cooperative Robotics efforts will be made to promote international operation through joint projects; to reinforce the teams with full time and post-doc researchers; to bridge the gap between theory and practice by pushing the collaboration with marine scientists, environmental experts and government agencies interested in the management of ocean resources and civil protection; to endow researchers with the infra-structures and technical personnel required for the development and testing of ocean equipment and vehicles.

In 2001 the Systems and Control Theory Group has launched a number of activities including seminars and two advanced courses on Optimization Theory and Dynamic Stochastic Estimation, Prediction and Smoothing. The seminars and courses were attended by a large number of Ph.D. students and faculty. The objectives of the Systems and Control Theory Group are: (i) to make up for the lack of advanced graduate courses in control theory offered by the University; (ii) to attract young students with a keen interest in theoretical developments in systems and control; (iii) to provide a forum for cross fertilization of ideas in emerging theoretical areas and; (iv) to give support to practical developments in challenging areas of systems' engineering.

The strengthening of the other ISR well established areas of research will be obtained by a better dissemination of research results within the international community; an increased participation in international scientific networks; the reinforcement of collaborative links with industry; and pursuing an aggressive policy of attracting foreign post-doc and Ph.D. students.

In 2001, 141 senior and junior researchers have developed their research activities within ISR (Lisbon Pole). These included 20 professors, 1 Principal Researcher, 4 post-docs, 51 Ph. D. Students, 26 M.Sc. Students, 35 undergraduate research trainees, and 4 Research engineers. Of the 51 Ph.D. Students, 19 are Teaching Assistants at the University or at other Higher Education institutions and the remaining 32 are grant holders (17 Portuguese and 15 foreigners). Of the 26 M. Sc. Students, 4 are Teaching Assistants at Higher Education institutions.

During 2001, the institute researchers have been involved in a large number of national and international R&D projects, financial resources being provided at a national (FCT, ICCTI, Ciência Viva, private companies) and international level (EU, and others), contributing to increase the international visibility of the institution. As a result of these activities 11 M.Sc. and 3 Ph.D. theses were concluded, 5 papers where published in books, 22 papers were published in well known international journals, and 78 papers presented at prestigious international conferences. Steps will be taken to encourage researchers to increase the publication of their research results in archive journals. Also the number of publications by Post-Docs is, in general, beyond expected and hence efforts should be made by their supervisors in order to change the situation.

The training of young researchers has pursued, involving 54 Ph.D. Students (Portuguese and foreigners) and 37 M. Sc. Students (Portuguese). Three researchers have concluded their doctoral theses, and 11 researchers have concluded their M. Sc. theses. Also, young licentiates from several European countries have come to participate in short and medium term research initiatives.

Several researchers have stayed short or long periods abroad, as visiting or invited professors, researchers or students.

The participation in editorial boards of international journals, and in the program committees of international conferences of high reputation was also very active.

Several foreign senior and junior researchers have visited and stayed with ISR.

Internal efforts were made to increase the cooperation links between different groups, in particular institute wide seminars were organized on a weekly basis with required participation of the students. Also and following comments made by the international evaluation panel the AIMS Lab and the IC Lab have started a discussion process aiming the merging of the two groups in a single Lab to be denominated Intelligent Systems Lab.

ISR is also organizing the 10th Mediterranean Conference on Control and Automation (MED2002) that will take place at IST in July 2002 with the support of the IEEE Control Systems Society.

As closing remarks we would like to stress the fact that the international visibility of ISR and in particular of some of his groups has increased significantly. This fact translates not only on the increasing number of foreign graduate students and post-docs wishing to pursue their research carriers at ISR, but also on the international contacts leading to collaboration projects and in the interest that Workshops and Conferences organized by ISR are raising in the scientific community.

Finally we urge again the host institution, IST, to recognize the research and graduate advising contributions of the faculty through differential classroom teaching assignments and trough the increase of administrative and technical support for all our laboratories.

João Sentieiro
ISR, April 30, 2002

1. INTRODUCTION

This report describes the activities developed, during 2001, by the ISR (Lisbon) members and collaborators. In terms of background the ISR (Lisbon) researchers come from two main areas: Electrical and Computer Engineering, and Mechanical Engineering.
This report is organized in four main chapters: The introduction chapter includes the reports of the Advisory Committee members. In chapter 2 the research team is identified and the research interests stated. Chapter 3 contains a full report of the activities of the members affiliated with the Department of Electrical and Computer Engineering of Instituto Superior Técnico (IST), with the Exact and Human Sciences Unit of the University of Algarve (UA) and with the Department of Mechanical Engineering of IST. This chapter is organized in subsections covering all relevant aspects of the research and academic activities pursued by ISR (Lisbon) researchers during 2001, namely research projects, supervision of Ph.D.and M.Sc. theses, courses and seminars, visits abroad, invited talks, editorial boards, program and technical committees, journal and conference reviewing and publications. In chapter 4 a description of the laboratories equipment and other facilities is provided.

1.1 Reports on visit to ISR-Lisbon of the Advisory Committee

Due to agenda difficulties and to the 11th of September events it was not possible, this time, to have all the members of the Advisory Committee (AC) visiting together the institution. Three visits were organized : two in October 2001 (Prof. Henrik Christensen and Prof. Panos Antsaklis) and one in February 2002 (Prof. Mos Kaveh). The three reports produced by the Committee members are presented in the following sections.

1.1.1 Report by Prof. Henrik Christensen

GENERAL IMPRESSIONS

RESEARCH QUALITY

- Much of the research is of international quality. A few examples include excellent research of significant international interest. A few efforts might not be of international quality and it might be important to focus research to ensure adequate resources are available.

RESEARCH FOCUS

- More explicit formulation of research focus/issues for each laboratory is desirable. The overall outlines are very useful but they are fairly generic. (The description by the DSOR lab is a good example of a more detailed statement, but concrete shorter term results/focus would be useful)
- Diverse, yet, strong research on most aspects of robotics.

RESEARCH MANEGEMENT

- Visionary and open management structure that encourages the pursuit of strong research agendas that are theoretically well-founded.
- Strong support for the different groups. The management seems to provide a most useful infrastructure for the largely independent research within each group.
- Overall management of the institution is *very* good. Given teaching requirements it is impressive to see an institution that has managed to strengthen its research effort to a level of good international recognition.

OBSERVATIONS

- International students might not be as closely integrated into the institution as one might wish for.
- Foreign placement for tenure track personnel. To ensure that tenure track personnel have a solid international perspective it is considered important that all junior researchers prior to entering the tenure track programme have spent a period of more than 6-12 month at a foreign research institution.

- Engineering resources needed. Significant resources by researchers and students seem to be used for basic engineering. A certain amount is desirable, but for extensive engineering it might not be efficient to use research time.

- Ambient intelligence should be considered. The focus of the next framework programme is "Ambient Intelligence". The diverse research platform at ISR might make it an important candidate for participation. In addition it might be important to monitor the possibility of participation in a "network of centers of excellence"
- The theory group has been setup. The group provides seminars etc. It is considered essential to strengthen the group and ensure that it is efficiently interfaced to the other research groups.
- The heavy teaching duty of faculty is still a major obstacle to widespread excellence. Only through unreasonable work efforts is it possible to maintain/setup an excellent research environment.

1. MOBILE ROBOTICS

The mobile robotics group is lead by Assoc Prof Maria Isabel Ribeiro and has a new assistant professor Joao Sequeira. In addition the group has 2 PhD students, and 2 MSc students. The research is focussed on mobile robotics. At present there are two major avenues of research: outdoor robotics and cooperative robotics.
In outdoor robotics the emphasis is on mapping using topographical models as a basis. The topographical models are augmented with local feature models. The focus is at present on basic mapping. The research is carried out in the context of a new outdoor vehicle (RWI ARTV-jr).
Implicitly the problem addressed is the fundamental problem of simultaneous localization and mapping, which traditionally has been formulated as a non-linear Kalman filtering problem. Through reformulation of the problem it is possible to use local models; this does however require development of local mapping techniques and methods for robust place recognition. The use of a variety of sensory modalities is required to address this problem. The project thus presents an excellent platform for studies of multi-sensory fusion. The use of GPS opens for studies of use of sensors that have stochastic availability, and non-deterministic delays. The platform can also be used for studies of fusion vision, inertial sensors and laser ranging. Overall a number of interesting results are expected in this area. One concern might be focus. To enable progress and pursuit of world class results it is recommended that a strong focus is defined for the project. General outdoor robotics is today a highly diverse area and it is considered difficult for a relatively small group to address many of these issues, consequently it is recommended that a specific focus is adopted.
The other major problem addressed within the group is cooperative robotics. Here in particular simulation a study of loose coordination of teams of robots has been studied as a basis for definition of strategies for collaboration. The problem of robot cooperation is interesting as it can encompass a number of diverse issues in terms of distributed sensing, local communication, ad hoc utilization of resources etc. Cooperation has frequently been addressed in terms of local interaction using basic control models such as impedance control. The idea behind this project is to project sensory derived model into a control manifold that can ensure coordinated motion of a team of robots. This is an interesting approach to coordination, but it might be useful to compare it to traditional methods so as to demonstrate it superiority. Again the problem of cooperative robotics is highly diverse and encompasses a large number of issues that only can be addressed in a meaningful manner through a strong focus on a particular sub-field. Once such area might be distributed sensing, communication models for coordination, ad-hoc resource management, etc.
In addition to the two major projects the group also has a number of exploratory projects on robotics and IT, and robots for inspection. Both projects are relatively small and meant to explore potential avenues for future research. The issue of IT systems and their use of robotics as an integral component is most timely. This is at present an issue of significant industrial attention. The integration of complex systems is by no means a trivial problem. There are however a number of existing standard for construction of systems and in addition it is necessary to consider all the diverse aspects of IT systems for automation to make real progress. The issue of robotics for inspection is another interesting problem that potentially might be of industrial interest. This is however a highly competitive market and it might be difficult to compete with large groups and industrial companies. None the less this is a good topic for student projects.
The group has a good collaboration with the intelligent control laboratory.
Overall the group seems to be on its way to change focus from laser range based modeling to the areas of outdoor navigation and cooperative systems. With proper focus on key issues the group has a potential to build up a strong competence in these areas. It might be useful to consider the set of international links with key research groups in USA (CMU, MIT) and Europe (Örebro, EPFL, Karlsruhe, CLAWAR).

2. DYNAMIC SYSTEMS AND OCEAN ROBOTICS GROUP

This group is headed by Associate Prof Antonio Pascoal. In addition Assistant Prof. Carlos Silvestre and Assistant teacher Paulo Oliveira, play senior roles in the coordination of the research. The group has 3 post doctoral researchers, 4 PhD students, and a large number of MS. c students.
The focus of the group is on dynamic systems and its application to oceanographic robot vehicles. The research is founded in well founded linear and non-linear models of vehicles and their control. For control of these vehicles hybrid control models encompassing discrete events (modeled using Petri-nets) and linear control systems have been studied.
The work has involved the design of a surface vessel (DELFIM), an oceanographic vehicle (CARAVELA) and a submersible (INFANTE). An interesting part of this research is the holistic approach to the research. The effort involves all aspects from theoretical modeling over algorithmic studies to engineering of operational systems. At the same time the systems include sensing, actuation, communication, electronic and real-time software development. This is a truly impressive effort. It is judged that the group is making solid progress on both theoretical issues and their empirical evaluation. The system has been tested in number of different settings.
Recently the group has also undertaken work on control of helicopters. The group has so far developed basic dynamic models for flight and is now ready for studies of sensor driven mapping and navigation. It is not immediately obvious why the group has chosen to expand their domain of application to aerial vehicles.
In addition to theoretical studies and engineering of systems the group is also actively involved in experimental use of the platforms for mapping and exploration with geologist and mine biologists. These studies have in particular been carried out at the Azores.
The group seems to have a particularly strong network of national and international collaborators. It is, however, not immediately obvious that there are good collaborative links to other groups within the institute. As an example both this group and the computer vision group have projects in underwater navigation, yet it is not obvious that complementary expertise is utilized.
There is little doubt that this is a very strong underwater robotics group that likely is among the best in Europe.
One concern is that the group is spending a significant amount of its resources on engineering in terms of electronic design, implementation, basic software design (home made software at all levels), and systems design. Funding of such activities might be difficult to obtain and it might be possible to sub-contract such engineering work to outside companies.
It is encouraging to see the solid theoretical basis and its implementation into operational systems. The group also seems to be reasonably well funded.

3. COMPUTER VISION LABORATORY

The group is headed by Prof. Joao Sentieiro, with strong support from Assistant Prof. José Santos-Victor and Assistant Prof. João Paulo Costeira. The group involves about 10 PhD students and 2-3 MSc students. In addition the laboratory has several visiting students.
The group does research on basic computer vision methods in particular based on motion and binocular cues. The information is used for generation of world models, and for navigation in the context of aerial, underwater and ground vehicles. More recently the research has also involved biologically inspired methods for world modeling and control. The research involves a strong combination of signal processing, geometry and control.

The research can be divided into four main directions:

i) active vision,
ii) vision for navigation
iii) 3D reconstruction and
iv) biologically motivated methods in vision.

The active vision work is directed at use of space variant sensing for ocular motor control. The research involves a combination of cue estimation, tracking and motor control. This is a long-term research effort within the group and the researchers involved have a strong record in this area. At present the research is aimed at computation of cues for front-end like representations as seen on human (V1-V5). The work involves disparity channels and band pass filters for motion estimation. In addition various segmentation methods are considered. Overall the work is interesting and of good quality. It would however be interesting to see a "systems perspective" on the work carried out. i.e. it is not immediately obvious that issues such as complexity, task dependency etc. are taken into account for this work. In addition it would be of interest to see integration with higher level processes where the issue of memory and representations becomes more pronounced.

The work on vision based navigation is one of the long-standing research challenges addressed within the group. A majority of the research is at present directed at use of omni-directional camera systems for navigation. A rich variety of topics are studied here including: perception-action integration, world representation, sensor design, learning of motion models and navigation strategies. It seems that a significant part of the work is directed at use of sensors that are composed from specially designed spherical mirrors in combination with space-variant sensors. Through this combination it is possible to design sensors according to task constraints. This is a more interesting area of research. It would however be of interest to see a more explicit formulation of task dependencies. As to the navigation the work is based on construction of a mixture of iconic and topological maps. The work is here a combination of semi-automatic mapping techniques and methods from pattern recognition. Overall the work is interesting and of solid quality. It would be of interest to see evaluation of these techniques in comparison to well established methods for in-door navigation. It is not obvious that thorough evaluations and metrics has been defined for this research and it is consequently difficult to assess the progress and/or benefits with respect to state of the art.

In terms of 3D recovery of models of the world based on monocular images and or binocular images two major lines of research have been pursued. The first line of research involves use of geometric constraints in combination with semi-automatic recognition of features for recovery of geometric shapes for polyhedral objects. The work utilizes constraints such as symmetry, co-planarity, planarity, linearity. This work is considered of high quality and largely in accordance with state of the art. The other effort within this area is related to optimal matching of pairs of images in the presence of outliers. The work is based on feature matching across pairs of images. The strategy is to consider a structured approach to selection of permutations of matching pairs to ensure a structured (non exhaustive) traversal of the search space. The work appears to be highly interesting but it would be of interest to see a comparison of this approach to some of the many methods (both optimal and sub-optimal) published in the literature. This is by no stretch a new problem.

The fourth area is related to biologically motivated methods for perception-action integration in particular related to learning by imitation and distributed motor representations. This is a natural extension of the research mentioned above and the major direction is here towards learning of presentations and control strategies. Both areas are of significant interest and most timely. The research is still at its infancy and it is too early to determine the potential of this research.

Overall the research is of good quality. One concern is that the group is undertaking a large number of research issues, and it is not immediately obvious that the different efforts have a common theme. It will be difficult to achieve international quality in the research without some focus. The problems could be solved through involvement of more academic staff or post-doctoral researchers. Alternatively the research could be focussed on a smaller number of topics.

The group has a strong set of international collaborators, which is highly encouraging. At the same time there is some collaboration with other groups within ISR, but would be of interest to see more work with groups such as the Dynamic Systems and Ocean Robotics Group.

1.1.2 Report by Prof. Panos Antsaklis

I visited ISR on Wednesday and Thursday, October 17 and 18, 2001 and I met with two research groups on Wednesday (Intelligent Control, AI and Manufacturing Systems) and with three on Thursday (Evolutionary Systems and Biomedical Engineering, Dynamical Systems and Ocean Robotics, Aeronautics). On Thursday I also had a one hour long meeting with a group of Ph.D. students and Post-docs as well as a one hour meeting with Senior Researchers from the groups I visited. In addition I met with Carlos Bispo and had several meetings with Joao Sentieiro and Michael Athans.

The contents of this report are as follows: The first part of the report summarizes the overall comments and suggestions regarding the research quality and focus; it also contains general comments and suggestions from the interviews I conducted with Graduate Students, Post-docs and Senior Researchers. The second part of the report contains brief comments and recommendations regarding individual research groups.

PART I

GENERAL COMMENTS AND RECOMMENDATIONS

Below please find a summary of my observations and recommendations regarding the five research groups I visited.

- The range and quality of research is significant, mostly of international caliber and in several cases truly impressive. The senior researchers as a group are very able and competent. Good work is being done and the ISR researchers should be proud of their accomplishments.

- The research activities involve a healthy mix of theory and practice-with some exceptions. This I think is the great strength of ISR and it distinguishes it from other university research institutions in Europe and internationally.

- It is apparent that the overall research leadership is excellent. The environment is friendly and amenable to research and scholarly activities.

- The new theory group is up and running. Current courses offered are in optimization and estimation. Novel research efforts include possible projects in mathematical biology and bioinformatics with emphasis on the mathematical modeling of the immune system. Such efforts should definitely be encouraged with additional resources. I hope that more people from ISR will be involved in them.

- Communications between laboratories could be improved. Some groups are interacting with the others, other groups do not interact as much. The Aeronautics group does not interact with anybody else in ISR.

- My recommendation is either to drop the Aeronautics group from ISR or better perhaps, to bring in a second faculty member (senior researcher) whose aim will be to establish within one year common ground and submit a joint proposal with other ISR groups.

- There is urgent need to improve infrastructure particularly Internet access speed, computer network administration and technical support, hardware and especially software support. I would recommend that ISR secures the services of a computer software professional who would be able to help the research groups and provide network support for ISR.

- It is highly recommended that a regular distinguished visitor lecture series be established. Perhaps a name could be attached to the series and outside funding may be secured.
- To improve opportunities for interaction, have regular seminars and regular coffee/tea hour. Use email to notify everyone about seminars and post notices on website. It may be a good idea to post resources and events (books, journals, presentations, tutorials) of each lab on the website.

- The increased support from Portuguese ministry of science and technology is good but not enough. Emphasize European projects primarily to gain visibility. Establish mechanisms to provide researchers relief from the heavy administrative burden of EU projects.

- A way to improve visibility is to organize international workshops. One such effort is currently under way (MED'02 Conference in Control and Automation)

- It appears that in each group the number of projects, the variety of project topics, the fact that many projects have a time-consuming hardware component, the number of graduate students and the significant teaching obligations do not leave enough time for the group leaders to identify and explore new promising research directions, to go after new large European research projects, and to build research teams for European level proposals (such activities not only bring in significant resources but also provide international visibility and a forum for the work at ISR to be measured against related work around the world). Ways to correct this serious drawback include reducing teaching loads, increasing the number of faculty in each group, focusing on fewer bigger research projects and providing infrastructure support in the form of software computer expertise.

FEEDBACK FROM THE GRADUATE STUDENTS AND POST-DOCS

On Thursday October 18, I had a one hour meeting with Ph.D. students and Post-Docs from the 5 labs I visited.

First, the students were asked to list on a sheet of paper 5 good things about ISR, 5 areas that they felt needed some improvement, and where they plan to be in 3-5 years. The following is a summary of the 16 responses:

Positive aspects of ISR:

1) The students recognized the expertise of the advisors and faculty, considering this a strong asset.
2) The students praised the reading groups and the opportunity to work with other students.
3) The variety of projects and research opportunities was another positive aspect because the different interests of the students are fulfilled.
4) Some of the students were pleased with the availability of resources, including the libraries and online journals.

Aspects of ISR that could use improvement:

1) While some of the students praised working with an advisor, others mentioned that they wanted more personal attention from their advisors. This might just be a problem with one or two of the advisors, and not a complaint across the board.
2) Many students complained about internet speed.
3) While the students enjoy working in groups, some suggested that there be more social interaction among people, as well as interaction with other teams. They also mentioned simply wanting to know what the other teams were working on - perhaps there could be more communication among the groups.
4) Some of the students complained about the lack of available (library, books, journals) resources, as opposed to the group above who were pleased with the options. It was also suggested that language classes (Portuguese) be offered to new foreign students.
5) Some students expressed a desire for more opportunities to speak internationally, as well as having more international speakers on a regular basis.

Then I invited them to bring up their comments, concerns and suggestions. Certainly there is significant overlap between the written and oral responses, as expected. Here are some of their comments.

1. Organize Portuguese language courses for new foreign students. This is very important if you want to have foreign students.
2. We need more courses offered by ISR for example on nonlinear control. Right now there are only courses on optimal control and estimation.
3. Some labs have reading groups. This is a good idea to be adopted by all groups.
4. Have regular tea-time to socialize and meet everyone.
5. Have regular seminars. It would be great to have distinguished lecturers on a regular basis. However, Professors need to show up at the seminars.
6. There is lack of integration in ISR. Some groups do no talk to any other ones.
7. Participation in international conferences by students should be encouraged.
8. The internet facilities are very slow and need to be improved.
9. Need cooperation with other universities in Portugal.

FEEDBACK FROM SENIOR RESEARCHERS

On Thursday October 18, I had a one hour meeting with Senior Researchers from the 5 labs I visited. Here are some of their comments:

- Improvements in infrastructure are needed. Most important is the upgrade of internet access. It appears that the access speed to the internet can sometimes be painfully slow leading to delays and frustration and to significant amounts of work loss.
- It appears that air conditioning and sometimes heating are effectively non existent. This situation also leads to work loss.
- Hardware and primarily software infrastructure support is needed urgently.
- Identity of ISR involves a healthy balance between theory and practice. This should be continued and encouraged further.
- There were concerns regarding library facilities-some groups have them other groups have no access. It was felt that IEEE digital access is important to achieving their research goals.
- As some groups have grown it is important to plan for new physical space for laboratories and offices.

PART II

The second part of the report contains brief comments regarding individual research groups. I met with two research groups on Wednesday (Intelligent Control, AI and Manufacturing Systems) and with three on Thursday (Evolutionary Systems and Biomedical Engineering, Dynamical Systems and Ocean Robotics, Aeronautics).

Intelligent Control Laboratory
Leader: Pedro Lima – Assistant Professor

Research topics of interest to the Intelligent Control group include hybrid systems, multi-robot systems, reinforcement learning, and non-linear estimation and control.

Currently, the group has activities in the areas of DES and Hybrid dynamical systems and in Reinforcement Learning. The presentation included a detailed description of how the group had addressed the points brought up in the previous (1998) advisory committee report. Most have been successfully addressed, however the area of interaction with other research groups both within the institute and outside still needs improvement. One talk was presented by a student on Hybrid Systems Abstraction and Composition. Applications included soccer playing robots, satellite formation control.

Overall the group uses Systems approaches to address problems typically drawn from the robotics and at the task coordination level. They are very familiar with the latest approaches in DES systems and the Ph.D. work of Paulo Tabuada is of high quality, theoretically very challenging work. It was rather surprising to see such highly theoretical work in a group where most of the other projects have a much more practical flavor.

This group is proposing to merge with the AIMS group with one of the joint projects being the multi-robot project.

I do like the work Pedro Lima is doing, but I think his efforts are being restricted by the fact that he is the only faculty in the group. Also a limiting factor in the group is the fact that there is no professional software (and hardware, but I do not think this is as severe) support, such as a systems specialist. Another issue, which I must mention is that I did not see participation in European projects among the group activities.

AI and Manufacturing Systems (AIMS)
Leader: Luis Custodio – Associate Professor

The Artificial Intelligence aspect of this group looks at emotion-based agents, multi-robotic agent systems, and spatial and pictorial reasoning. The Manufacturing Systems aspect of this group studies the control architectures for manufacturing systems.

Professor Carlos Ferreira has not been able to participate in group research due to other commitments. The third member Carlos Bispo has research interests that are rather different from this group's interests. I met with Carlos individually to discuss his research and made recommendations regarding research focus areas.

An overview of the activities was presented by Luis Custodio and then individual students presented summaries of their projects.

There are two main research areas currently pursued, one that involves Emotion based Agent Systems and another that concentrates on issues regarding multi-agent systems with emphasis on the emotion based area.

It is an active group with many conference publications and some journal publications. It seems to be one of the primary groups in emotions AI research internationally.

This group is proposing to merge with the AIMS group with one of the joint projects being the multi-robot project.

I could make similar comments as for the IC group, namely: I think the efforts of this group are being restricted by the fact that there is only one active faculty in the group. Also a limiting factor in the group is the fact that there is no professional software (and hardware, but I do not think this is as severe) support, such as a systems specialist. I did not see participation in European projects.

Regarding both groups IC and AIMS and the proposed merger:

There is no critical mass of senior researchers in either of the groups, there are too many different projects for the number of faculty, there is not much time for cooperation with other groups, for looking up new research directions and for building up research teams for European level proposals (such activities not only bring in resources but also provide visibility and a forum for the work at ISR to be measured against related work around the world).

I do find the idea of merging the two groups overall very attractive. Even in this case however, the new group may not have critical mass in terms of number of active faculty and I would recommend that additional faculty be added. Another way is of course to reduce the teaching loads of these people. Ideally both should be done.

I think that it is very important to give access of these groups to a technician and a software specialist. Such person may be shared by several groups.

Regarding projects where both groups may work on, it has been suggested that a multi-agent robot project is a candidate. I would like to support this suggestion but enhance the problem by considering larger number of robot agents, with hard real-time constraints and perhaps limited communication abilities. Such systems (networked, embedded) are becoming increasingly important in a wide range of applications.

Evolutionary Systems and Biomedical Engineering:
Leader: Agostinho Rosa – Associate Professor

This group focuses its research on the development of algorithms with gene oriented paradigms and gene oriented crossover and mutation operators.

This is an active group with international partnerships. The fact that there is only one faculty in the group is a drawback.

The group has significant expertise in EEG research and research in this area should be continued and should be emphasized. Smaller projects such as development of algorithms based on "Cultural Information" and social networks, although interesting they should be conducted in the background. This applies also to the project on the "Olive Fly." Emphasize strength areas (EEG). The JAVA library of evolutionary algorithms the group has developed and made available is quite impressive.

Recommendations include exploring research possibilities in the area of bioinformatics, focusing the research, reduce the number of MS projects if they distract from main research activities, and go after EU projects that provide access to major resources and increased visibility.

Dynamical Systems and Ocean Robotics:
Leader: Antonio Pascoal-Associate Professor

This is a very successful and well-managed group with strong international reputation. They work on great topics combining theoretical research with exciting applications in the area of ocean robotics, the leadership is first class, their presentations were very well prepared and impressive. This group is a success story and its work should be supported as much as possible. Their work is an excellent combination of theory and practice in a topic very appropriate for Portugal and her marine traditions and should serve as a model for the other groups.

The group has designed and constructed autonomous underwater vehicles and has developed advanced systems for navigation, guidance and control, acoustic communications, and mission management. Current projects include the study of hydrothermal phenomena and the mapping of marine habitats. Projects include the cooperation between a surface vessel and an underwater vehicle and involve research in signal processing, guidance and control and underwater communications.

It is apparent that this group can use some relief from underwater vehicle construction and maintenance so to focus further on more research oriented issues.

Aeronautics:
Leader: Luis Campos – Full Professor

This group looks at flight testing, flight dynamics, flight simulation, aerodynamics, sound generation, sound propagation, and hydro magnetic waves.

Currently most projects are in acoustics and they include sound propagation in nozzles, blade vortex interaction, sound generation by propellers and acoustic fatigue. They are mostly theoretical projects that involve modeling and analysis. There are additional projects in flight dynamics that involve the separation of aircraft while landing and in magneto hydrodynamics involving solar wind. The group is involved in European projects.

I did not meet Professor Campos but I was given his resume. The group has a large number of papers that primarily appear to highlight Professor Campos's expertise. In all papers, Professor Campos's name appears first. I would strongly recommend that students should take a more leading role in research and present papers in international conferences.

I was very disappointed by the fact that there is no attempt whatsoever to integrate this group's research with the research of the other groups in ISR. It is not clear what anybody gains by having this group part of ISR.

There are very exciting new research areas, such as coordination of multiple AUV's, etc.. where expertise in flight dynamics would be helpful in joint projects. Unfortunately Professor Campos is very busy and successful with his current research in the analysis of acoustic phenomena to have time to explore new areas and ways to bring his group closer to the research directions the rest of the ISR groups pursue.

My strong recommendation is either to drop this group from ISR or better perhaps, to bring in a second faculty member (senior researcher) whose aim will be to establish within one year common ground and submit a joint proposal with other ISR groups.

1.1.3 Report by Prof. Mos Kaveh

OVERVIEW

ISR is a dynamic center of research with considerable strengths in systems, signal processing and controls. The staff and the students at the Institute continue to make contributions in both the theoretical and applications side of the mentioned disciplines, with hardware and experimental work primarily focused on a variety of robotics applications, including underwater autonomous vehicles. The existence of experimental projects provides students, even those outside of robotics, a more balanced exposure to hardware and practical issues than is often the case in most academic electrical engineering control and signal processing laboratories.

The Institute has a dedicated and active faculty, many outstanding students, and a fair and visionary leader. The Institute has implemented a number of suggestions that were made at the time of the last visit by the External Advisory Committee in 1998 . These positive developments include the establishment of a Theory Group and the offering of advanced graduate courses in several key topics, the institution of a seminar series for student researchers and visitors, and the establishment of a PhD course requirement. There is, of course, mixed feelings on the part of the students regarding this new PhD course requirement. The students, nevertheless, would like to see a greater variety of courses, particularly in signal processing and communications. Also, the students prefer seminar talks that are more shorter with more time for discussion. Consideration should also be made to the establishment of a mechanism for early review of thesis proposals by a committee consisting of faculty from at least two laboratories. This can serve as a quality control measure, and as a process for cross-pollination of ideas and possible increase in collaborations among different laboratories.

Several accomplished young faculty members have, or are about to join the Institute. The accomplishments and research promise of most of these faculty members compare favorably with their counterparts in first rate universities in Europe and the US. As in the case of their mentors at the ISR, these young faculty members are in great need of administrative support, reduced teaching loads and merit-based promotions to bring their scholarly promise to full fruition. The discussions that have commenced in this regard at the instigation of Prof. Athans is a positive first step toward possible implementation of policies that recognize outstanding research in addition to good teaching, and that will serve to move ISR to even higher levels of excellence and international recognition. This, in turn, should help attract greater number of international students and visitors to the Institute.

The graduate students are highly appreciative of the accessibility of the research faculty. Nevertheless, they worry that too much administrative load reduces the availability of thesis advisors for direct student supervision. Students and faculty also continue to be concerned about the general lack of administrative and computer system support, and access to electronic journals. They acknowledge that some improvements have been made at the university in support of research contract administration, although management and coordination of major contracts still consume substantial faculty time. The bulk of the general administrative load for the Institute continues to be on the Director, although some changes, in the form of assignment of associate directorship has recently been implemented.

The following gives a summary of the observations on the three laboratories that were visited.

COMPUTER VISION

The Computer Vision Laboratory is led by a combination of highly accomplished senior and junior faculty members. The Lab is primarily concerned with vision-based systems and image processing for robotics applications. Within this framework, research on a set of theoretical issues, such as learning and control, and technological innovations for sensing, such as omni directional camera systems, and specially-designed mirrors, have been pursued. The Laboratory has developed a wide range of expertise and basic technological know-how that can be extended to other areas utilizing computer vision, for example in traffic management. The group is quite active, and disseminates its research findings in major international journals and conferences. The projects have and continue to be funded by European and Portuguese sources.

Key projects in the Computer Vision Group can be classified as falling in the areas of:

1. Active vision and robot learning through imitation and development
2. Robot navigation with omni directional vision
3. Visual underwater navigation
4. 3-D reconstruction of structured scenes from multiple 2-D projections

The Lab's more recent work in active vision has moved into methods based on log-polar image representation, biologically-inspired system models, imitation and learning. In this regard collaboration with psychologists and some level of interaction with the Evolutionary Systems and Bioengineering Laboratory might be of benefit.

Vision-based navigation is heavily based on the development of omni directional cameras and mixed mirror sensors designed for focus on, and resolution of environmental features that are useful for navigation. These are complemented with work on the development of topological maps and information sampling. The work appears (to a non-specialist) to be of high quality. Given the broader interest in the integration of sensors and information processors, the approach that is followed here can serve as an example of interesting work in the future that goes beyond camera-based sensors for robot navigation.

The work on visual underwater navigation (NARVAL) is concerned with the construction of a mosaic map of the sea floor to use for navigation and servoing. Inherent difficulties with a visual system in this medium include low visibility, non-stationary lighting and environment and computational burden. Field data has been obtained and processed, and an experiment has been conducted with French collaborators. Extensions to non-planar sea bottom and design of the robot controller are planned. It appears that the basic techniques related to the use of mosaic registration for determining trajectories have applications beyond the underwater problem. It seems natural to expect some level of collaboration on this project with the Dynamical Systems and Ocean Robotics group.

A number of approaches and applications are being pursued that are related to 3D reconstruction and motion estimation. Basic research issues are concerned with the use of occlusions for 3D structure and motion, polyhedral approximations of structured 3D scenes from multiple images and optimal reconstructions (maximum likelihood) and uncertainty analysis of the reconstructions. The work seems quite solid, and the examples and applications seem to be quite diverse.

EVOLUTIONARY SYSTEMS AND BIOENGINEERING

This is a rather large and diverse group that is led by one faculty member. The projects appear to have little in common. However, they are mostly biologically inspired, use evolutionary computational techniques (genetic algorithms), and utilize a computational toolset that has and continues to be developed within the group. This set of software, The Java Distributed Evolutionary Algorithms (JDEAL) is openly available through the Lab's web site, and has apparently received attention by many research groups.

The best-known sustained work of the lab is related to sleep EEG analysis. This work clearly has international visibility, and is supported by several national and international collaborations, such as one with the Stanford University Medical School. Other examples of the group's most recent, current, and future projects include:

1. Artificial life
2. Planning and scheduling
3. Object recognition from feature networks
4. Use of EEG for cognitive studies and recognition of emotions.
5. Image enhancement

The object recognition project is nearly finished, EEG work is ongoing with applications to drowsiness, sleep and road accidents. The artificial life work is concerned with the simulation of an agricultural pest problem - the olive fly, while topic 4 is to be carried out in the future, given appropriate support.

For its size and level of activity, the Lab is low on research funds. However, the topics are popular, attract a large number of students. Collaborations with hospitals and other entities for data acquisition and experimentation seem to be critical to the generation of scholarly results and theses. Indeed, the lab's conference and journal publication output in 2002 promises to be quite healthy, after two years of decline following the Lab Director's sabbatical.

Observations and suggestions

- The Lab director is visionary and appears to have established an intellectually stimulating environment for work at the interface of several disciplines. In principle, such cross-disciplinary activities can be an important source of discovery, and should be encouraged.
- National and international collaborations are extensive and strong. Co-advising by advisors of students who have come to the Lab from other institutions is an interesting concept for strengthening cross-institutional links. The co-advisors', however, do not appear to be actively involved in the supervision of the projects.
- A number of the projects have matured and are much better defined than they were at the time of the Committee's previous visit.
- The creation of JDEAL, and its open dissemination, if successful, is a good source of visibility for the Lab and the Institute.

- Diversity of the projects and the size of the group make advising and quality control of theses challenging.
- Publications are in widely varying disciplines (medical, computing, neural nets). While the breadth of disciplinary coverage is admirable, it is more difficult to gain strong visibility for the Lab in a particular field.
- A number of graduate students in the group come from non-EE, computing or physics/math programs. Appropriate disciplinary underpinnings must be provided to these students for a PhD degree in electrical engineering.
- More interaction with other groups within ISR would be desirable. Examples of possible projects that could benefit from such interactions include work in computational biology and computer vision and image processing based on the human visual system. Students from the Lab should be encouraged to give presentations on their work at the Institute seminar series.

SIGNAL AND IMAGE PROCESSING

The Signal Processing Laboratory has the largest number of faculty members of any Laboratory within ISR (soon to be nine faculty members in Lisboa, and two at Algarve). With one possible exception (Prof. Simoes?) all the faculty members have been active in research of high international quality in the past three years. A large number of publications and presentations have appeared in leading journals and conferences of the field. Professors Lourtie and Barroso and duBuf have had associate editorial responsibilities within the IEEE Signal Processing Society and the Int. Journal. of Pattern Recog. and AI, respectively, and Prof. Barroso continues to be highly visible within the signal processing community in the US. For example, in addition to serving on a technical committee of the IEEE Signal Processing Society, he has served on a proposal evaluation panel of the US National Science Foundation. The new group of assistant professors have superb research credentials that should serve the Laboratory well in the coming years. The Lab continues to have a strong funding base. For

example, special programmatic funding has been allocated for Signal Processing for Wireless, and the Diatom project coordinated by Prof. duBuf at Algarve.

The primary projects in the Lab can be classified as:

1. Signal processing for robotics applications
2. Underwater acoustics and communications
3. Image processing and pattern recognition
4. Statistical signal and array processing, and signal processing for wireless

The Signal Processing Lab has had a number of fruitful collaborations with other laboratories of the Institute that are primarily concerned with robotics applications. Given the substantial effort within the institute on various robotics and autonomous vehicle projects, this collaboration can continue to be a source of interesting signal processing projects that utilize and benefit real working systems.

The Lab (at Lisboa and Algarve) has considerable strength in the area of underwater acoustics, signal processing and communications. Time-frequency analysis techniques and underwater acoustic topography are hallmarks of the techniques developed by the members of the Laboratory. The work is of outstanding quality, collaborations within and outside the Lab are strong, and the Lab appears to enjoy considerable visibility within the underwater acoustics community. Planned projects related to deep water topography and ocean environmental modeling based on acoustic inversion seem very challenging and interesting. The underwater acoustics and signal processing work at Algarve seems to have considerable level of synergy with the activities in Lisboa.

Image processing and pattern recognition activities in the Lab include ultrasound imaging and shape tracking based in Lisboa (Prof. Marques), and visual perception, pattern recognition and identification of diatoms (unicellular algae) at Algarve (Prof. duBuf). The work appears to be of high quality and with specific applications. The Algarve leadership of the Diatom project is noteworthy. The ultrasound work is concerned with 3D reconstruction in the presence of nonlinear compression in ultrasound scanners using statistical techniques. This is interesting work, and provides nice potential avenues of interaction with medical applications. However, there is considerable work done in ultrasound imaging for dealing with speckle, for example by using second harmonic filtering. It is not clear how the work being carried out in the Lab compares with the state of the art. The work on shape tracking based on multiple switched models is also very interesting. Given other activities within the Institute related to computer vision, and biomedical applications, the image processing work can benefit from cross-laboratory collaborations. However, the vision work at Algarve seems less synergistic with the activities in Lisboa, and its relation to ISR is not as clear.

The Lab has established itself as an outstanding center of research in signal processing for communications with considerable international visibility. This is a direct result of the group's contributions to the general area of statistical signal and array processing. The regional/local needs and opportunities have resulted in key contributions to underwater signal processing and communications. This has motivated the understanding of some difficult channel models, and the development of algorithms to deal with limitations of such channels. At a more basic general level, the group has contributed scholarly work to blind identification of channels, including MIMO systems that are gaining considerable interest in wireless communications. The special funding for signal processing for wireless, and the incoming staff members should boost the group's activities in this area. Related to this work, the ISR group has the opportunity to more closely interact with the wireless and microwave communication systems groups in the Telecommunications Institute of IST. While some level of interaction exists, the potential for more significant collaboration is great. I visited the microwave laboratory. The equipment and expertise in this lab can provide an experimental infrastructure for channel modeling and signal processing for wireless that is seldom found in leading academic signal processing groups.

2. RESEARCH TEAM AND INTERESTS

2.1 MEMBERS AND COLLABORATOR

THEORY GROUP:

Michael ATHANS, *Principal Researcher*

ARTIFICIAL INTELLIGENCE AND MANUFACT. SYSTEMS:

Carlos PINTO-FERREIRA, *Associate Professor*
Luis M. CUSTÓDIO, *Assistant Professor*
Carlos BISPO, *Assistant Professor*
Sandra GADANHO, *Post-Doc*
Jorge Miguel PAIS, *Adj. Professor, Ph.D. St.*
Rodrigo VENTURA, *Teaching Assistant, Ph.D St.*
Nuno ORFÃO, *Teaching Assistant, Ph.D St.*
Márcia MAÇÃS, *M.Sc. St.*
Ivone FERNANDES, *M.Sc. St*
Bruno DAMAS, *M.Sc. St.*
Pedro VALE, *M.Sc. St*

COMPUTER AND ROBOT VISION :

João SENTIEIRO, *Full Professor, ISR/IST Director*
José SANTOS-VICTOR, *Assistant Professor*
João Paulo S. A. COSTEIRA, *Assistant Professor*
Alexandre BERNARDINO,*Teach.Assist.,Ph.D. St.*
José GASPAR, *Teaching Assistant, Ph.D. St.*
Nuno GRACIAS, *Ph.D. St.*
Etienne GROSSMAN, *Ph.D. St.*
João MACIEL, *Ph.D. St.*
César SILVA, *Ph.D. St.*
Niall WINTERS, *Ph.D. St.*
Raquel VASSALO, *Ph.D. St.*
Claudia DECCÒ, *Ph.D. St.*
Lenildo SILVA, *Ph.D. St.*
Freek STULP, *Ph.D. St.*
Manuel LOPES, *Ph.D. St.*
Sjoerd van der ZWAAN, *M.Sc. Researcher*

EVOLUTIONARY SYSTEMS AND BIOMEDICAL ENG. :

Agostinho ROSA, *Associate Professor*
Fernando MELÍCIO, *Adj. Professor, Ph.D. St.*
Rogério LARGO, *Adj. Professor, Ph.D. St.*
Tito SILVA, *Ph.D. St.*
Osvaldo BRASAO, *Ph. D. St.*
Hongfei GONG, *Ph.D. St.*
Cristian MUNTEANU, *Ph.D. St.*
José MALAQUIAS, *Ph.D. St., Teaching Assistant*
Ernesto SOARES, *Ph. D. St.*
João Paulo CALDEIRA, *M.Sc. St., Teaching Assistant*
Rui TAVARES, *M.Sc. St., Teaching Assistant*
Carlos FERNANDES, *M.Sc. St.*
Nelson *PEREIRA, M.Sc. St.*
Henrique PEREIRA, *Research Project*
Weng Hong TANG, *Undergrad. St.*
Alexandre CALAPEZ, *Undergrad. St.- BIC*
Sergio CHIN, *Undergrad St.*
Djamilo JACINTO, *Undergrad St.*
Atila NEVES, *Undergrad. St*
Miguel COSTA, *Undergrad St. – BIC*
Ivo BHATT, *Undergrad. St*
Andre BALTAZAR, *Undergrad. St*
Pedro SOEIMA, *Undergrad. St*
José Carlos REIS, *Undergrad. St*
Sara ALI, *Undergrad. St*
Nuno COSTA, *Undergrad. St*
Fernando CONTREIRAS, *Undergrad. St*
Marco ERRA, *Undergrad. St*
Pedro MITRA, *Undergrad. St*
Nidia CALDEIRA, *secretary*

INTELLIGENT CONTROL :

Pedro LIMA, *Assistant Professor (IST)*
Paulo TABUADA, *Ph.D. Student*
Dejan MILUTINOVIC, *Ph.D. Student*
Sónia MARQUES, *Ph.D. Student, Teaching Assistant (IPS)*
Paulo ALVITO, *M.Sc. Student, Teaching Assistant (IPS)*
João PINA, *M.Sc. Student, Teaching Assistant (FCT/UNL)*
Carlos MARQUES, *M.Sc. Student*
Hugo FURTADO, *M.Sc. Student*
João FRAZÃO, *Undergrad St*
Paulo SARGENTO, *Undergrad. St*
Hugo COSTELHA, *Undergrad. St*
Gonçalo NETO, *Undergrad. St*
Pedro PINHEIRO, *Undergrad. St*
Duarte SEGURADO, *Undergrad. St*
Carlos SANTOS, *Undergrad. St*
Pedro PEREIRA, *Undergrad. St*
Victor GOMES, *Undergrad. St*

MOBILE ROBOTICS :

Maria Isabel RIBEIRO, *Associate Professor*
João SEQUEIRA, *Assistant Professor*
Alberto VALE, *Ph.D. Student*
José Paulo CASTRO, *M.Sc. Student*
João G. MOTA, *M.Sc. Student*
Sérgio GUERREIRO, *M.Sc. Student*
Inácio ROCHA, M.Sc. Student
Nuno SILVA, *Undergrad. St*
Nelson GONÇALVES, Undergrad. St
Pedro SILVA, Undergrad. St

SIGNAL PROCESSING : (IST)

Victor BARROSO, *Associate Professor*
Isabel LOURTIE, *Associate Professor*
Jorge S. MARQUES, *Associate Professor*
Pedro AGUIAR, *Assistant Professor*
Francisco GARCIA, *Assistant Professor*
João Pedro GOMES, *Teach. Assistant, Ph.D. St.*
João XAVIER, *Teach. Assistant, Ph.D. St.*
João SANCHES, *Teach. Assistant, Ph.D. St.*
Jacinto NASCIMENTO, *Ph.D. St.*
Paulo M. de OLIVEIRA, *Ph.D. St.*
Jorge BARBOSA, *Ph.D. St.*
Dusan RAMLJAK, *Ph.D. St.*
Emanuel RIBEIRO, *Ph.D. St.*
Pedro JORGE, *Ph.D. St.*
Rui CRUZ, *M.Sc. Student*
Paulo LOPES, *Undergrad St.*
Tiago PATRÃO, *Undergrad St.*
Rui F. C. GUERREIRO *Undergrad. St*

SIGNAL PROCESSING : (U.ALGARVE)

Sérgio JESUS, *Associate Professor*
Hans du BUF, *Invited Associate Professor*
Hamid SHAHBAZKIA, *Assistant Professor*
Orlando C. RODRIGUEZ, *Assistant Professor*
Mário C. M. JESUS, *Adjoint Professor*
António João SILVA, *Adjoin Professor, Ph.D. St.*
Paulo FELISBERTO, *Adjoin Professor, Ph.D. St.*
Robert LOKE, *Ph.D. Student*
João RODRIGUES, *Ph.D. Student*
Luis SANTOS, *Ph.D. Student*
Pedro GUERREIRO, *Ph. D St.*
R. LAM, *Ph. D St.*
Cristiano SOARES, *M.Sc. St.*
Nelson MARTINS, *M.Sc. St*
Bruno SILVA, *Undergrad. St.*

DYNAMICAL SYSTEMS AND OCEAN ROBOTICS :

António PASCOAL, *Associate Professor*
Carlos SILVESTRE, *Assistant Professor*
Sergey RUMYANTZEV, *Post-Doc*
Leonel LAPIERRE, *Post-Doc*
Didik SOETANTO, *Post-Doc*
Paulo OLIVEIRA, *Teach. Assistant, Ph.D. St.*
Pedro ENCARNAÇÃO, *Ph.D. St.*
António AGUIAR, *Ph.D. St.*
Francisco TEIXEIRA, *PhD. St.*
Fei CHUN MA, *Ph.D. St.*
Sajjad ASL , *Ph.D. St.*
João ALVES, *M.Sc. St.*
Carlos FERREIRA, *M.Sc. St.*
Miguel PRADO, *M.Sc. St.*
Luella WONG, *M.Sc. St.*
Rita CUNHA, *M.Sc. St.*
Pedro ALVES, *M.Sc. St.*
Luis SEBASTIÃO, Res. *Engineer*
Manuel RUFINO, Res. *Engineer*
Telmo AZEVEDO, *Research Technician*
Nuno FERRAZ, *Undergrad. St.*
Álvaro PIRES, *Undergrad. St.*
Paulo SANTOS, *Undergrad. St.*
Rui SIMÕES, *Undergrad. St.*

ADMINISTRATIVE STAFF:

Filomena VIEGAS
Loic BANDÉ
Nuno SENA

AERONAUTICS :

Luís M. Braga da Costa CAMPOS, *Full Professor*
Fernando P. LAU, *Assistant Professor*
Paulo J. S. GIL, *Assistant Professor*
Filipe S.R.P. CUNHA , *Invited Professor*
António J.N.M. AGUIAR , *Invited Assistant*
Jorge M.P. GOMES, *Assistant*
Pedro G.T.A. SERRÃO, *Teaching Assistant, Ph.D. Student*
João M. G. OLIVEIRA, *Teaching Assistant, Ph.D. Student*
Pedro M. V. MIRANDA MENDES, *Ph.D. Researcher*

Mª Fernanda VENÂNCIO, *Secretary*
Ana D. MORGADO, *Secretary*
Sónia Varela BORGES, *Secretary*

2.2 CURRENT RESEARCH INTERESTS

The Lisbon pole of ISR is internally organized in 8 laboratories/groups. In this section the main research interests of each one of the Laboratories/groups are briefly described.

2.2.1 INTELLIGENT CONTROL (IC)

The main research problems pursued at the Intelligent Control Lab are:

the control of complex and/or large-scale systems, the implementation of real-time process and (cooperative or individual) robot control architectures encompassing low-level control, sub-systems coordination and task planning.

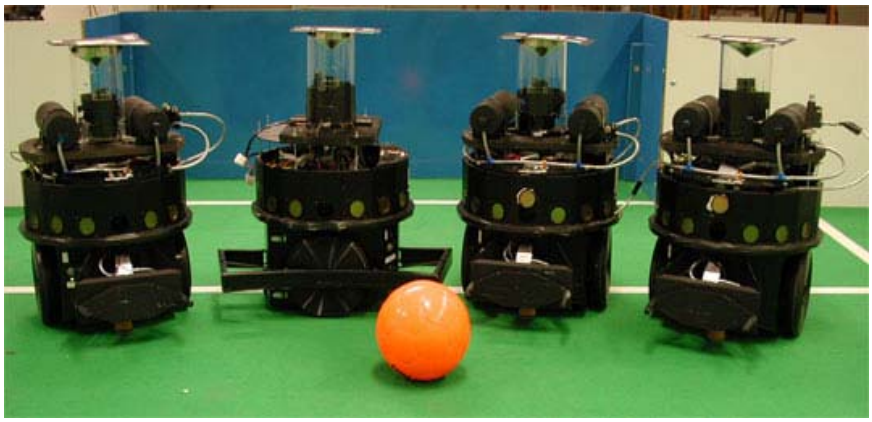
The research topics include:

- **Hybrid Systems**: study of control systems composed of a supervision/coordination sub-system (event-driven) and one or more sub-systems which interact directly with the controlled system/environment. The group is currently more interested in the applications of hybrid systems to the performance analysis and synthesis (from specifications) of robotic tasks, especially through the use of Petri nets and hybrid automata .

- **Multi-Robot Systems**: analysis and synthesis of a population of robots designed to achieve specific goal(s) through cooperation between the population members. The group is currently interested in the application to Robotic Soccer, where the environment is full of static (walls, stopped robots) and dynamic objects, including repulsive (other robots) and attractive dynamic objects (the ball), as well as to Robotic Rescue in situations of large-scale disasters (e.g., earthquakes, building collapse).

- **Reinforcement Learning**: this is a specific type of learning appropriate for applications to robotics, with potential, to be linked to the work on Hybrid Systems and Multi-Robot Systems.

- **Non-Linear Estimation and Control**: this topic is mainly motivated by the group work on satellite attitude estimation and control. Also mobile robot guidance requires considerable knowledge from this area.



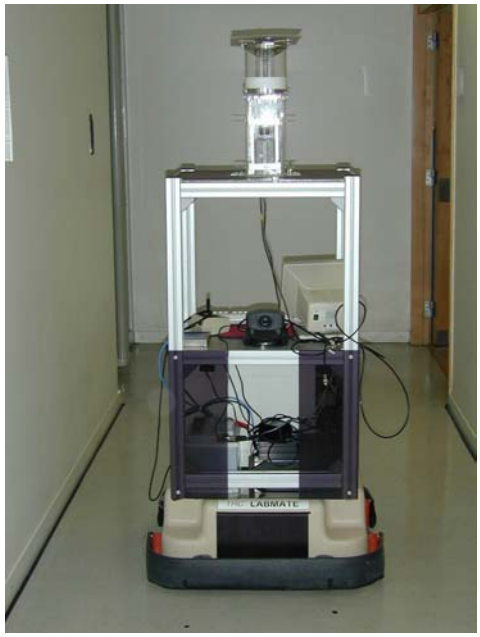
2.2.2 COMPUTER AND ROBOT VISION (VIS)

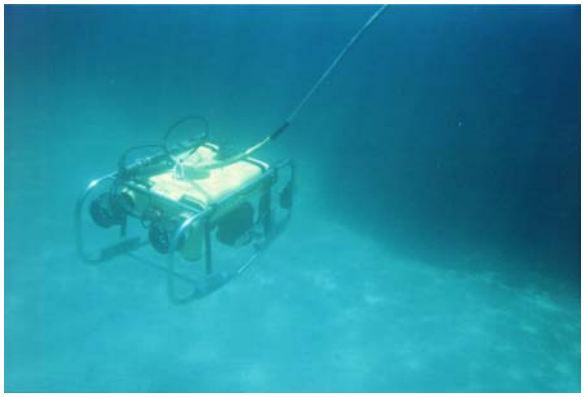
The research conducted in the Vislab is organized in two main lines:

- **Vision Based Control and Navigation**
- **3D Motion analysis and Reconstruction**

When a camera is moving in a static (or dynamic) environment, the image sequence conveys information regarding the scene/objects structure and camera/objects motion.

In the theme of ***Vision Based Control and Navigation***, we address the fundamental problems of understanding what *relevant* information can be extracted from the image sequences to *control* a robot in order to perform a *given task*. This has long standing research line of the Vislab including the control of extremely varied systems like the active control of a binocular head, vision based navigation for land, aerial and underwater vehicles and teleoperated cellular robots. From the foundation, VisLab has addressed the control of Binocular Systems and a land mobile robots. More recently, the research was extended to vehicles moving in the 3D space, such that the interplay between the vehicle's degrees of freedom and the scene structure is significantly richer. Example applications have focused on lighter than air blimps and underwater vehicles, in the context of European Research Projects. One distinctive aspect is the search for alternative imaging geometries, often inspired after biological findings. Extensive work has been carried out in the domain of using omni directional images for navigation and control as well as for map building for indoors robots. In addition, we have pursued the usage of non-metric maps for navigation like topological maps for structured environments and video mosaics for underwater navigation.





The theme of ***3D motion Analysis and Reconstruction*** is devoted to the geometry of retrieving information about the scene structure 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 key step in most 3D vision systems. In addition, the depth estimation process has been formulated in an optimal way by itself. Another line of research has been the reconstruction of structured scenes (e.g. buildings) making use of auxiliary geometric information provided by the user.

Research in all these topics has ben carried out both at 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 ARTIFICIAL INTELIGENCE AND MANUFACTURING SYSTEMS (AIMS)

The research conducted in the AIMSlab is organized in two main lines:

- Emotion-based Agent Systems
- Multi (Robotic) Agent Systems

Emotion-based Agent Systems

Recent research on the neurophysiology of human emotions suggests that human decision-making efficiency depends deeply on the emotions mechanism.eneral methodology of this research consists of the study of the neuroscience findings (e.g., Damásio and LeDoux works) and research how these results/theories/hypothesis might be used/interpreted/adapted for designing better or different (artificial intelligence) agents.

> "*The problem is not whether intelligent machines can have emotions,*
> *but whether machines can be intelligent without any emotions*"
> [Marvin Minsky, The Society of Mind]

• development of an **emotion-based agent architectures**, which is an entity whose behaviors is designed through a conceptual interpretation/implementation of the hypothesis/theories formulated in the neuroscience area, related with human emotions, namely the concepts of primary and secondary emotions, somatic marker hypothesis, stimuli double and parallel processing, conditioning, "movie-in-the-brain". The research methodology is based on experimentation either with virtual or real environments

• study how an emotion-based architecture might be articulated with a **classical rational-based architecture** (which includes knowledge representation, reasoning, learning, planning, to name but a few).aking a known (classical) tool and integrate it with our architecture, for instance, Logics (reasoning), Reinforcement Learning (learning), STRIPS (planning).

• formalize the conceptual framework developed in order to have a **formal modelling tool** for analysing and synthesizing emotion-based agents (for instance, using Theory of Categories, Drama Theory (a re-definition of Game Theory that assumes non completely rational decision making).

Multi (Robotic) Agent Systems

In the context of Cooperative Robotics, in order to obtain useful cooperation, relationships among robots have to be accomplished, because of the existence of dependencies between agents' actions, the definition of global constraints and goals, and the fact that each individual might have insufficient competence, resources and information to solve the problem *per se*.

So, the goal of this research is the development of general methodologies for teamwork in a multi-agent system, specially for multi-robot system, capable of dealing with complex and dynamic environments, working coherently as a group of agents, handling different and even opposite views of the world and problem, allowing flexible communication among team members, evaluating the team performance, and implementing re-organization strategies to handle unexpected situations.

• define the underlying individual agent architecture, specially both individual and cooperative **knowledge (or belief) representation**, (e.g., Logic-based, behaviour-based, hierarchical-based, Belief-Desire-Intention);

• develop a formal **reasoning (or belief revision)** mechanism for updating knowledge (or belief), establishing and terminating cooperative actions, evaluating its pre-conditions, choosing which agents participate and deciding which agents might have the initiative to establish cooperation, for instance, based on First Order Logic (e.g., Joint Intentions Theory), Modal Logics (e.g., LORE logic), True-Maintenance System, Bayesian inference, Game Theory, Contract Nets;

• design a **planning and scheduling** tools of cooperative actions for distributing them among the agents handling limited resources, and re-planning in order to recover from failures, based on Distributed Planning (e.g., Shared Plans Theory), Distributed Constrained Heuristic Search

2.2.4 MOBILE ROBOTICS (MR)

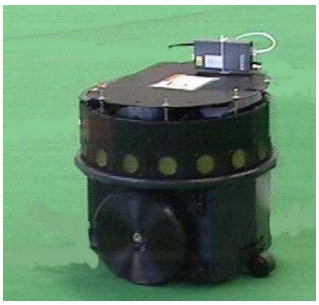
The Mobile Robotics Lab activities focuses on the research, development and testing of robotic tools applied to the control and navigation of autonomous mobile robotis.
In this Laboratory we are particularly interested in the issues of:

mobile robot navigation, in structured and semi-structured environments,
cooperation/collaboration among multiple robotic devices,
robotics and information systems.

- **Mobile robot navigation**: Study of navigation architectures for the operation of mobile robots in structure and semi-structured indoor environments, including obstacle detection and avoidance, path planning, trajectory finding, motion control and localization. Different sensors are used, namely ultrasound and laser. The group is most interested in the establishment of new sensor and world representations aiming at simplifying the navigation tasks, namely to overcome the absolute localization required in most tasks. The study of probabilistic approaches for the Localization and Map Building in outdoors environment aiming at search and rescue operations is currently under study.

- **Cooperative robotics**: Multiple heterogeneous robots (mobile platforms and manipulators) acting together towards the fulfilment of an assigned task. A behaviour-based approach to the control of each single robot has been considered. Formal aspects of the behaviour-based control architectures were studied using tools from algebraic group theory. These led to a conceptual control architecture of hybrid nature, with a supervisor modelled by a finite discrete automaton and a set of classes of continuous models modelling robot motion. A distinctive feature of these continuous models is that they accept (in the sense that an assigned mission can be successfully executed) a broad range of robot trajectories.

- **Robotics and information systems**: Information systems are one of the cornerstones of most of the modern organizations. Furthermore, the use of CASE tools in organizations management/operation led to the development of abstract modelling languages of which one of the most widely used is UML (Universal Modelling Language). The biological inspiration has been used in many areas of robotics, such as sensors and robot control architectures. Furthermore, the recent explosion of cooperative robotics is also absorbing paradigms from social evolution models to minimize the complexity of the problem. A similar approach was followed to design a robot control architecture based on a business modelling framework. Unlike the classical approach, this robot control architecture is defined for each mission assigned to the robot and it is revised each time an event in a pre-specified set is triggered. It is also expected that the overall methodology can be applied to robot teams.



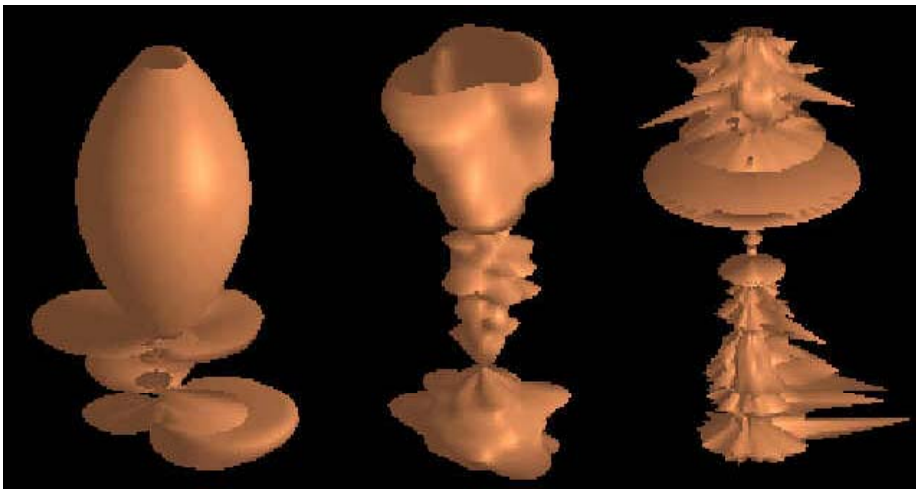
2.2.5 SIGNAL AND IMAGE PROCESSING (SP)

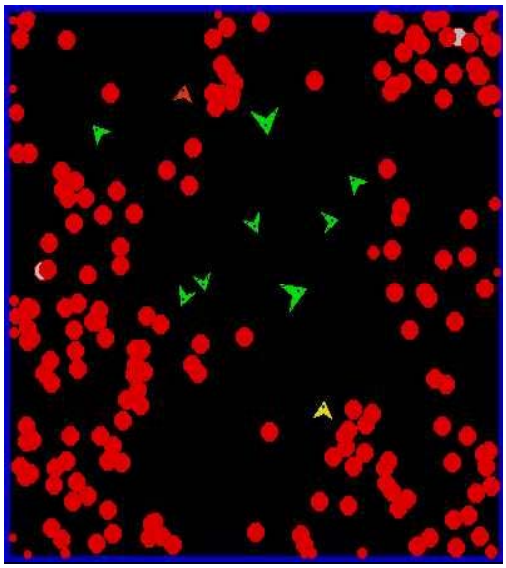
- **Statistical Array and Signal Processing**
- **Wireless Communication Systems**
- **Underwater Acoustic Data Communications**
- **Detection and Estimation Theory**
- **Time-Frequency Signal Analysis and Processing**
- **Navigation and Guidance of underwater vehicles**
- **Image Processing**
- **shape analysis**
- **video surveillance**
- **pattern recognition**
- **Image analysis**
- **Computer vision**
- **Video processing**
- **Multimedia signal processing**

2.2.6 EVOLUTIONARY SYSTEMS AND BIOMEDICAL ENGINEERING (ESBE)

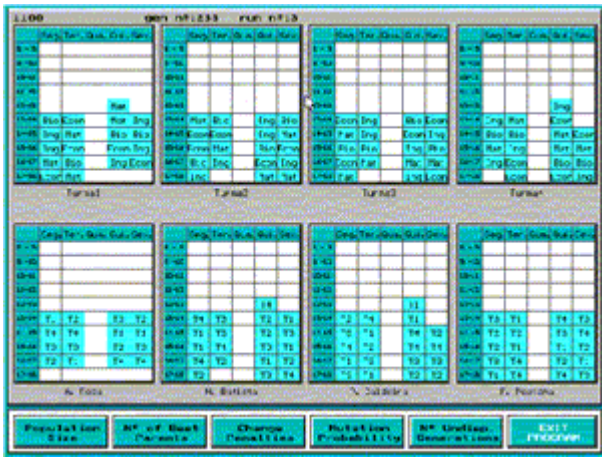
In the last three years a great effort has been directed to the development of the new areas of Evolutionary Computation and Computational Intelligence. An application oriented approach has been the early focus and will remain so, but recently the attention has been more directed towards methodology and paradigm areas. Current research in this new objectives are: Development of algorithms with gene oriented paradigms instead of individual or chromosome centered. New gene oriented crossover and mutation operators (infection operators) have been devised and applied; more applications and general conceptual framework undergoing. The symbiotic/synergetic use of Evolutionary Computation with Artificial Life simulation models (as insect colony optimization, disease simulation and prediction, etc). The initial steps for the application of Evolutionary Computation in the area of Computational Molecular Biology will be taken.

On the Biomedical Engineering area, the core work on sleep research will proceed with international cooperation. The area of cognitive science linked to the EEG as brain computer interface will be the next point of further exploration.

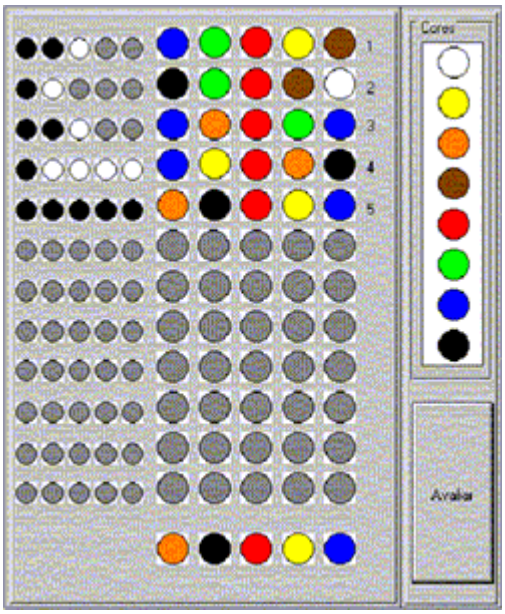




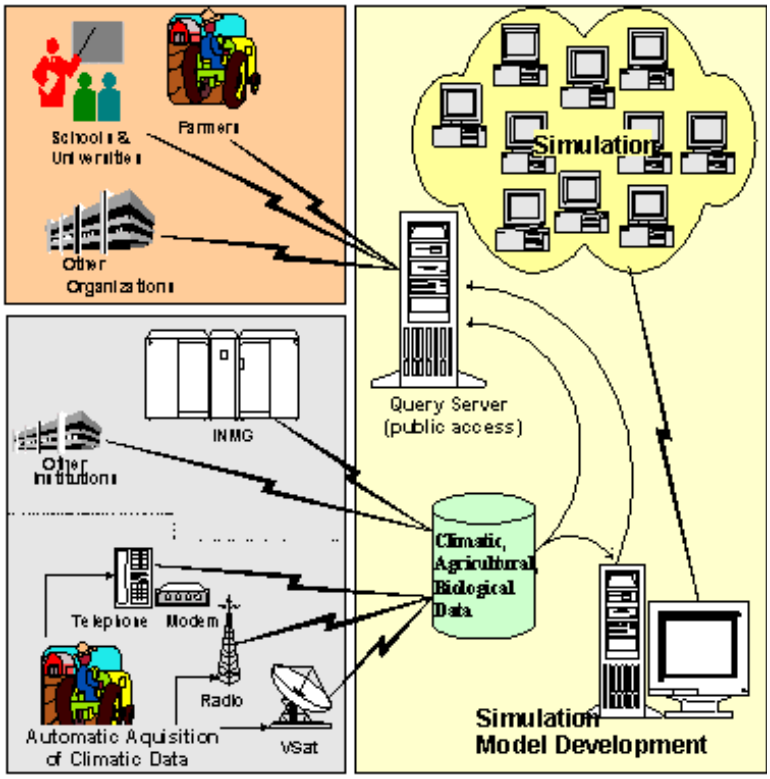
Gaia - Virtual Reality Artificial Life Simulator



School Timetable Scheduling using Genetic Algorithms



Search Problems Solving unsing Evolutionary Search



Integrated Protection of Crops Using Artificial Life Simulation

2.2.7 DYNAMIC SYSTEMS AND OCEAN ROBOTICS (DSOR)

The research and development work carried out at the Dynamical Systems and Ocean Robotics Laboratory (DSORlab) of ISR aims at contributing to furthering the knowledge in the general area of dynamical system theory and applying newly developed analysis and design tools to the control and operation of robotic ocean and air vehicles.

Over the past the few years, research work has been focused on the study of advanced linear and nonlinear system theory and their use in the development of new methods for autonomous vehicle navigation, guidance, and control. Considerable effort has also been placed on the study of hybrid systems for mission control of robotic vehicles, to enable the analysis and design of entities that capture the interplay between time-driven and event-driven systems.

The development work has led to the construction of the robotic ocean vehicles DELFIM (an autonomous surface Catamaran), INFANTE (an autonomous underwater robot), and CARAVELA (an autonomous oceanographic vessel). These vehicles play the dual role of i) *advanced testbeds*, to field test new system theoretical concepts, and ii) *platforms for actual operations at sea*, effectively paving the way for a fruitful symbiosis between marine science and technology. This follows the successful development of MARIUS, the first civilian European autonomous underwater vehicle for coastal oceanography in the scope of a project coordinated by ISR/IST, under the auspices of the Commission of the European Communities. The DSORL has also played an active role in the design, implementation, and at sea testing of the navigation, guidance, control, and mission control systems of SIRENE, an underwater shuttle for the automatic deployment of benthic laboratories developed in the scope of a European project coordinated by IFREMER, France.

Currently, the DSORL is involved in a number of projects and concerted actions with national and foreign institutions with the objective of advancing engineering methodologies and equipments to the point where they can be used as versatile tools to expand our understanding of the oceans. At a technological level, this concerted effort is in line with the current trend worldwide, aimed at the development of ocean sampling networks (OSN) providing a nested ocean observation capability through the coordinated control of many, mobile, networked, sensor platforms. This trend shows clearly that advancements in marine robotics, communications, and information systems are steadily being brought to bear on the development of technologies to enable safer, better, faster, and far more efficient methodologies for the study of the oceans. At the same time, the plethora of engineering problems that must be tackled and solved in the context of ocean research pose considerable challenges to theoreticians and system designers.

The CARAVELA Auto
Ocean Vessel – 1:3 scaled model

The DELFIM ASC and INFANTE AUV
1:1 models

Recently, and as a natural consequence of a longstanding collaboration program with the Department of Aeronautics and Astronautics of the Naval Postgraduate School of Monterey, California, USA, the DSORL has started to apply some of the methods and technologies developed for ocean vehicles to the control of air robots. Again, the activity pursued in the area is well rooted in scientific applications that require the use of autonomous air robots to accurately map coastal areas subjected to erosion.

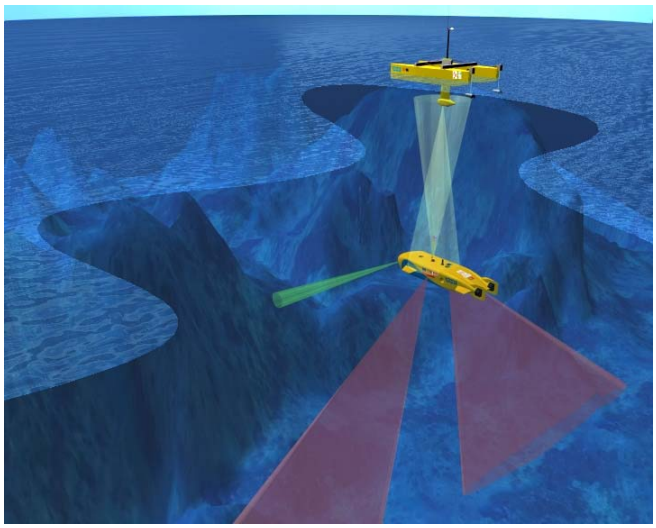
At a theoretical level, the main lines of research that are being pursued at the DSORL are the following:

Control of Nonholonomic and Underactuated Vehicles : stabilization of underactuated ocean robots in the presence of unknown ocean currents, actuator saturation, and vehicle parameter uncertainty using Lyapunov-based techniques, back stepping, and switched hybrid control.

Trajectory Tracking and Path Following Control : development of linear and nonlinear control strategies for accurate trajectory tracking /path following. *Linear designs* build on gain-scheduled control theory and exploit the use of Linear Matrix Inequalities. *Nonlinear designs* resort to back stepping techniques and explicitly address the problems of parameter uncertainty. Considerable emphasis has been placed on the development of innovative methods that combine some of the desirable characteristics of both trajectory tracking and path following, i.e. time convergence to the trajectory, while maintaining the smooth behavior during the initial approach to that trajectory that is normally associated with path following. Work is also being done towards the development of sensor-based path following control laws for ocean vehicles using vision and sonar.

In the air robotics area, work has progressed on the development of an accurate helicopter mathematical model for effective control system design and flight envelope expansion. The dynamic modeling focused on two-bladed single main rotor helicopters, and included a mathematical description of Bell-Hiller servo-rotors. The helicopter was modeled as a six degrees of freedom rigid body, actuated by forces and moments, which are generated at the main and tail rotors, fuselage, and empennage. Models for different flight regimes will be validated against the full nonlinear helicopter simulation model, providing the working ground for future system identification and control design / implementation for an existing helicopter that has been fully instrumented.

Coordinated Vehicle Control : multiple vehicle control for the execution of joint missions at sea. The main practical motivation for this work stems from the need to operate an autonomous surface craft (ASC) and an underwater vehicle (AUV) at the same time, along the same projected horizontal path, while keeping the two vehicles aligned along a vertical line (ASIMOV concept). See the figure below, where the AUV plays the role of master and the ASC that of slave in charge of relaying acoustic transmission from the AUV to a support ship. See also the following pictures that capture two phases of a mission exercise in the Azores, during the Summer of 2001, where the ARIES AUV of the Naval Postgraduate School of Monterey submerged, stabilized at a desired depth, and ran along a path identical to that of the DELFIM ASC, while communicating with it via an acoustic modem. The theoretical solutions adopted bear some affinity with those adopted for combined trajectory tracking and path following. At this stage, however, they do require the exchange of a large amount of information between the two platforms. Future work must address the problem of coordinated vehicle control under severe bandwidth constraints.



Coordinated vehicle operation: the ASIMOV concept

Joint operation of the ARIES AUV and DELFIM ASC in the Azores, Summer of 2001

Navigation System Design: new methods for navigation system design are being developed using the theory of multi-rate, polytopic, and linear parametrically varying systems. The main goal is to develop methodologies that can afford system designers with frequency-like design / analysis tools, thus extending to the time-varying and nonlinear setting the highly practical and intuitively appealing complementary filtering structures. The research activity in this area witnessed also the development of vision-based nonlinear complementary filtering structures for air and undersea applications.

Control of Ocean Vessels in the Presence of Waves: the problem addressed is that of designing acceleration feedback control systems for precise maneuvering and wave disturbance attenuation of hydrofoil craft. The design methodologies explore simple key physical relationships and build on gain scheduling control techniques.

Mission Control Systems (MCSs) : at the mission control level, work has continued on the development of software and hardware tools for mission programming and mission execution of autonomous vehicles, including cooperative control of surface and underwater vehicles. This work was instrumental in enhancing the capabilities of the Petri-net based software application named CORAL, proprietary of ISR/IST. At the same time, hardware architectures were developed for distributed real-time control of ocean robotic vehicles. Intensive series of tests at sea showed the reliability of the overall Mission Control System (MCS) developed. Namely, during the Summer of 2001, the DELFIM ASC successfully completed a series of seabed map building missions totaling up to more than 40 hours of operation in a purely autonomous mode, under the supervision of its MSC. During these missions the vehicle performed a grid survey, executing path following maneuvers in the presence of shifting sea currents and wind, while collecting acoustic data from a sidescan and mechanically scanned pencil beam sonar. The data were later processed to obtain high resolution seabed maps.

2.2.8 AERONAUTICS (AERO)

In Aeronautics:

- Flight testing, including development of instrumentation packages;
- Flight dynamics, including non-linear stability and atmospheric effects;
- Flight simulation: installation of a three degree-of-freedom simulator;
- Aerodynamics: installation of an aero acoustic wind tunnel.

In Acoustics:

- Sound generation by aircraft propellers and helicopter rotors;
- Sound propagation in ducts of varying cross-section with flow (nozzles);
- Scattering of sound in shear flows, including boundary layers and shear layers.

In Magneto Hydrodynamics:

- Hydromagnetic waves in inhomogeneous and flowing media;
- Applications to solar atmosphere and wind.

In Applied Mathematics:

- Differ integration, i.e. derivatives and integrals of non-integer order;
- Special functions, i.e. extensions of the hyper geometric type;
- Ordinary differential equations with regular and irregular singularities.

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 2001, 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 ROBOTICS

Project name: **NARVAL -** NAVIGATION OF AUTONOMOUS ROBOTS VIA ACTIVE ENVIRONMENTAL PERCEPTION

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

Project description: The goal of this project is to develop *non-intruding* and *reliable* navigation systems giving the robot the ability to select natural landmarks, and to navigate with respect to them, extending in this way the autonomy range of autonomous robots operating in *unknown and unstructured environments*. *Reliability* is achieved by continuously controlling the uncertainty associated with knowledge of the environment and of the robot's position and orientation. In the context of the project, *non-intrusiveness* means that the robot must be able to operate without special purpose landmarks being added to its environment. Non-intrusive operation in *unstructured environments* precludes navigation with respect to a set of handcrafted "landmarks," and requires the robot's ability to infer its position from learned natural landmarks of the environment using its perception system. Instead of passive reconstruction of the working space, perception is faced as a process of selectively extracting from the world the information needed to accomplish a given task, trading generality for specificity and gaining in simplicity and robustness. It is no longer a separate off-line module, but an integral part of the closed loop control system. This coupling will be explicitly addressed at the control level by assessing the compatibility of the current state of the robot's knowledge of its environment, its mission and safety requirements. Availability of such systems has a considerable impact in many economic, social and industrial activities such as control of marine pollution, surveillance of restricted areas, surveillance of equipment, agriculture, underwater cartography and marine biology studies, to mention but a few.

Research Areas: Computer Vision, Signal Processing, Navigation
Laboratories: Vislab - Computer Vision Lab (coordinator), Signal Processing
External Partners: I3S (CNRS- Université de Nice Sophia Antipolis) (FR), Thomson Sintra ASM (FR), DIST - University of Genova (I).
Initiated: 1998
Expected conclusion: December 2001
Classification: Esprit LTR Project – 30185
Documents produced in 2001: [30] [73] [74] [77] [79] [80]

3.1.2 UNDERWATER AND OCEAN ROBOTICS

Project name: DEVELOPMENT OF VEHICLES AND ADVANCED SYSTEMS FOR THE EXECUTION OF UNDERWATER INSPECTION TASKS - **INFANTE**.

Project Leaders: Prof. João Sentieiro (IST/ISR), Prof. António Pascoal (IST/ISR), Prof. Victor Barroso (IST/ISR)

Project description: The objectives of this project are the design and the construction of an autonomous underwater vehicle (AUV), and the development and integration of advanced systems for navigation, guidance and control, acoustic communications and mission management. These systems will be tested in the lab. Once they are installed in the vehicle, they will be also tested in pool and sea trials.

Research Areas: Control Theory, Computer Vision, Signal Processing, Underwater Acoustics.
Laboratories: Underwater Robotics, Signal Processing, Computer and Robot Vision.
External Partners: CINTAL-Univ. do Algarve (P), RINAVE (P), Instituto Hidrográfico (P)
Initiated: 1997
Expected conclusion: 2001
Classification: PRAXIS XXI 3/3.1/TPAR/2042/95
Documents produced in 2001: [96] [99] [102] [135] [137] [151]

♦

Project name: **ASIMOV** - Advanced System Integration for Managing the Coordinated Operation of Robotic Ocean Vehicles

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

Project Description: Three major stumbling blocks have so far prevented demonstrating the potential applications of Autonomous Underwater Vehicle (AUVs) to demanding industrial and scientific missions. Namely, i) the lack of reliable navigation systems, ii) the impossibility of transmitting data at high rates between the AUV and a support ship at slant range, and iii) the unavailability of advanced mission control systems that can endow end-users with the ability to plan, program, and run scientific / industrial missions at sea, while having access to ocean data in almost real-time so as to re-direct the AUV mission if required. As a contribution toward solving some of the abovementioned problems, this project puts forward the key concept of an Autonomous Surface Vehicle (ASV) that will operate in close cooperation with an AUV, as a mobile relay for fast communications. In the scenarios considered, the ASV will be equipped with a differential GPS receiver, an ultra short baseline unit (USBL), a radio link, and a high data rate communication link with the AUV that will be optimized for the vertical channel. Thus, by properly maneuvering the ASV to always remain in the vicinity of a vertical line with the AUV, a fast communication link can be established to transmit navigational data from the DGPS and USBL to the AUV, and ocean data from the AUV to the ASV, and subsequently to an end-user located on board a support ship or on shore. Fast and reliable communications, as well as precise navigation, will thus be achieved by resorting to well established technologies.
The main thrust of the project is the enhancement and integration of proven technological systems to achieve coordinated operation of an AUV and ASV, while ensuring the integrity of the two platforms. To give the work greater focus, the final goal of the research and development effort is to perform a mission at sea - near the Azores islands - down to depths of 100 m, to determine the extent of shallow water hydrothermalism and to determine the patterns of community diversity at the vents in the area. In the envisioned scenario, the AUV will be asked to maneuver close to the seabed and to detect the occurrence of bubble emissions from discharging vents. The detection of those phenomena will in turn trigger the acquisition and transmission - to a support unit - of time/space stamped sonar and video images through the vertical acoustic channel, via the ASV.
Obstacle avoidance and bubble detection will rely heavily on the development of a space-stabilized sonar head with vertical and horizontal transducer elements, and the associated signal processing algorithms.
Programming, executing, and modifying on-line the plans for joint ASV/AUV operation will be made possible by developing dedicated systems for joint mission and vehicle control, as well as appropriate Human-Machine interfaces.

Special emphasis will be placed on demonstrating all the steps that are necessary to acquire, process, manage, and disseminate data on hydrothermal activity to a wide audience of scientists, over the Internet.

Research Areas: Navigation, Guidance, and Control, Acoustic Communications, Obstacle Detection and Avoidance, Sonar Systems, Mission Control of Autonomous Vehicles, Ocean Robotics.
Laboratories: Dynamical Systems and Ocean Robotics Lab (DSORL)
External partners: ORCA Instrumentation (FR), GESMA - Laboratory of the French Navy (FR), ENSIETA - School of the French Navy (FR), System Technologies (UK), University of the Azores (PT).
Initiated: January 1998
Conclusion : 2001
Classification: Contract No**:** MAS3-CT97-0092 (Commission of the European Communities), Programme MAST-III (Marine Science and Technology) of the EC, 1998-2000).
Documents produced in 2001:

♦

Project name: NAVIGATION SYSTEMS WITH APPLICATIONS TO AIR, SURFACE, AND UNDERWATER VEHICLES.

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

Project Description: This research program aims at introducing new methodologies for the design of navigation systems for autonomous robotic vehicles to meet stringent stability and performance requirements.

1) Using simple kinematics relationships, the problem of estimating the velocity and position of an autonomous vehicle can be solved by resorting to special bilinear time-varying filters. These are the natural generalization of linear time-invariant complementary filters that are commonly used to properly merge sensor information available at low frequency with that available in the complementary region. Complementary filters lend themselves to frequency domain interpretations that provide valuable insight into the filter design process. The main purpose of the research program initiated is to extend those properties to the time-varying setting by resorting to the theory of linear differential inclusions and by converting the problem of weighted filter performance analysis into that of determining the feasibility of a related set of linear matrix inequalities. Using this set-up, the stability of the resulting filters as well as their "frequency-like" performance characteristics may be assessed using efficient numerical tools that borrow from convex optimization theory. Applications are being made to the design of navigation systems for air and underwater vehicles.

2) The problem of estimating the position and velocity of an autonomous vehicle by relying on inertial and vision sensors has received considerable attention over the past few years. Classical solutions rely on the use of Extended Kalman Filters. However, the resulting filters lack performance and stability guarantees. The main objective of the research effort undertaken in the course of this project is the extension of complementary filtering to a full non-linear setting by resorting to the theory of linear parametrically varying systems. The resulting filters are stable and exhibit a structure that exploits the complementarity of vision and inertial sensor data at low and high frequencies, respectively. Applications are being made to the design of navigation systems for air vehicles for automatic landing on aircraft carriers.

Research Areas: Filtering Theory, Nonlinear Time-Varying Systems, Polytopic Systems, Linear Matrix Inequalities.
Laboratories: Underwater Robotics Lab.
External Partners: Dept. Aeronautics and Astronautics, Naval Postgraduate School, Monterey, California.
Initiated: 1996.
Conclusion : ongoing
Classification: Memorandum of Understanding between the ISR/IST and the NPS. Research work supported by NATO scholarships and institutional funding for travel and accommodations.
Documents produced in 2001: [37] [100] [103] [132] [137] [139] [162] [166]

Project name: AUTONOMOUS VEHICLE DESIGN AND CONTROL

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

Project Description: The objective of this research program is twofold: i) to develop methods for integrated design of underwater vehicles and dynamic controllers, and ii) to study new methodologies for guidance and control of autonomous robotic vehicles, including those subject to nonholonomic constraints. The main thrust of the research effort addresses the following topics:

i) *Integrated design of underwater vehicles and controllers* - the methodologies explored are firmly rooted in the field of control systems theory and borrow heavily from the areas of Linear Matrix Inequalities (LMIs) and Convex Optimization, which are the subject of current research.
ii) *AUV control under wave disturbances* - the main theoretical tools used are stochastic linearization and linear matrix inequalities. The first allow computing the "linear simplified model" of a full stochastic model for the AUV; the latter are specially suited to address multiobjective design criteria such as minimizing the effect of wave action while maintaining sufficient control authority for depth maneuvering and robustness against plant uncertainty.
iii) *Path following in 3-D* – the key issue in this research topic is the control of air and ocean vehicles for accurate path following in 3-D. The methodologies being used borrow from Lyapunov stability theory.
iv) *Control of nonholonomic vehicles* – new methodologies are being explored to design nonlinear controller for nonholonomic vehicles for stabilization to a point with a desired orientation. The work has focused on the design of hybrid control systems that rely on the switching of a finite set of controllers, driven by the occurrence of observable external events.
v) *Control of surface craft using acceleration feedback* – the problem addressed is that of designing acceleration feedback control systems for precise maneuvering and wave disturbance attenuation of hydrofoil craft. The design methodologies explore simple key physical relationships and build on gain scheduling control techniques.

Research Areas: Combined Plant / Controller Optimization, Control Theory, AUV Dynamics, Linear Matrix Inequalities.
Laboratories: Underwater Robotics Lab.
External Partners: Dept. Mechanical Engineering and Dept. Aeronautics and Astronautics, Naval Postgraduate School, Monterey, California, USA
Initiated: 1996.
Conclusion : on going
Classification: Memorandum of Understanding between the ISR/IST and the NPS. Research work supported by NATO scholarships and institutional funding for travel and accommodations.
Documents produced in 2001: [97] [101] [131] [135] [136]

♦

Project name: **MONAZ** - "MONTEREY-AZORES: COOPERATIVE APPROACHES TO UNDERWATER FILED OBJECTIVE DETECTION AND MAPPING.

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

Project Description: The objective of the project is to study, develop, and test advanced systems for the coordinated operation of two underwater vehicles: the PHOENIX AUV (US Naval Postgraduate School, Monterey, CA, USA) and the INFANTE AUV (Instituto Superior Técnico, Portugal). The envisioned missions aim at determining the spatial extension of hydrothermal vent fields in the Azores, at close range. This projects builds heavily on the results obtained in the project ASIMOV. Its main thrust is the coordinated operation of two AUVs: i) the INFANTE AUV will carry a broad search in an area to detect the occurrence of hydrothermal activity, and ii) the PHOENIX AUV will receive (via the INFANTE AUV) the coordinates of the regions where the hydrothermal activity is judged relevant after which it will approach and conduct hovering maneuvers over selected hydrothermal vents for close range inspection. This is possible in view of the smaller size of the PHOENIX AUV.

Research Areas: Navigation, Guidance, and Control, Obstacle Detection and Avoidance, Sonar Systems, Mission Control of Autonomous Vehicles, Ocean Robotics.
Laboratories: Dynamical Systems and Ocean Robotics Lab (DSORL)
External Partners: Center for Autonomous Underwater Vehicle Research – Department of Mechanical Engineering, US Naval Postgraduate School, Monterey, CA (USA), Instituto Superior Técnico / Institute for Systems and Robotics (PT), IMAR/DOP/Univ. Azores (PT).
Initiated: July 1998
Conclusion : September 2001
Classification: Office of Naval Research (US), 1998-2001.
Documents produced in 2001: [134]

♦

Project name: CARAVELA - DEVELOPMENT OF A LONG RANGE AUTONOMOUS OCEANOGRAPHIC VESSEL

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

Project Coordinator: IMAR / University of the Azores (PT).

Project Description: The objectives of the project are to design, develop, and test the systems that are required for the operation of a long range autonomous oceanographic vessel. This is an innovative concept worldwide. The project addresses a wide range of issues that include: i) vehicle design, ii) propulsion, iii) communications, iv) obstacle detection and avoidance, v) navigation, and v) advanced systems for vehicle and mission control. In a representative mission scenario the vehicle will be required to traverse a specified area and collect and transmit selected oceanographic data to a support unit. The vehicle can be operated in a fully autonomous mode. However, its mission can be changed via high level commands issued from a laboratory installed on–shore. The project partners include the Portuguese companies RINAVE and CONAFI in charge of naval engineering aspects and vehicle construction, respectively. These companies are expected to promote the utilization of the vehicle by scientific and commercial entities, and to explore the possibility of its commercialization.

Research Areas: Navigation, Guidance, and Control, Communications, Obstacle Detection and Avoidance, Mission Control of Autonomous Vehicles, Ocean Robotics.
Laboratories: Dynamical Systems and Ocean Robotics Lab (DSORL)
External Partners: RINAVE Registro Internacional Naval (PT), Instituto Superior Técnico / Institute for Systems and Robotics (PT), CONAFI (PT), System Technologies (UK), SIMRAD (NO).
Initiated: October 1998.
Conclusion : December 2001.
Classification*:* Programmes PRAXIS XXI (PT) and EUREKA (Commission of the European Communities).
Documents produced in 2001: [96] [99] [102] [135] [137]

Project name: **FREESUB** - Autonomous Underwater Vehicle for Sub sea Intervention

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

Project Coordinator: Cybernetix Offshore Department, France.

Project Description: The " FREESUB " network addresses the exchange of human resources that are essential to the development of autonomous unmanned sub-sea vehicles (AUVs) for remote intervention on fixed underwater structures. The network's goal is to aid mobility of scientific researchers, technology transfer, and dissemination of information. The " FREESUB " network fosters the exchange of young doctoral and post-doctoral researchers among various EU universities and research institutes. The main technical objective of the project is to develop general tools that will (in the near future) allow autonomous vehicles to navigate to target sites with great precision and to carry out intervention tasks on underwater fixed structures.

Research Areas: Navigation, Guidance and Control of Marine Vehicles
Laboratories: Dynamical Systems and Ocean Robotics Lab (DSORL)
External Partners: CEA Teleoperation and Robotics Department (F), Democritus University of Thrace (Gr), The Joint Research Centre of the European Commission (I), Instituto Superior Técnico (P), University of Southampton (UK), UKIFREMER (F).
Initiated: October 2000
Conclusion : October 2003
Classification: Human Potential Research Training Network No. HPRN-CT-2000-00032
Documents produced in 2001: [132] [136] [137] [163] [164] [165] [167] [169] [170] [171]

♦

Project name: **MAROV** - Mapping of Marine Habitats in the Azores using Robotic Vehicles

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

Project Coordinator: ISR

Project Description: This project puts forward the concept of marine habitat mapping using an autonomous surface vehicle (ASV) and an autonomous underwater vehicle (AUV) equipped with acoustic and vision systems. The ASV allows for the mapping of large areas of the seabed (albeit with low resolution) using acoustic sensors. Furthermore, it acts as an interface between the AUV and a support ship. The AUV is used for higher resolution acoustic mapping, ocean data acquisition, and video and photo image taking closer to the seabed. Data obtained by the two vehicles and other complementary "classical" sources (for example, divers or towed systems) will be geo-referenced, analyzed by marine geologists and biologists, and processed to generate composites of benthic ecosystems using a Geographic Information System (GIS).

Research Areas: Marine Habitat Mapping Techniques
Laboratories: Dynamical Systems and Ocean Robotics Lab (DSORL)
External Partners: IMAR and Department of Oceanography and Fisheries, Univ. Azores, IGM – Geological Survey of Portugal.
Initiated: December 2000
Conclusion : December 2003
Classification*:* PDCTM, FCT (PT)
Documents produced in 2001: [96] [98] [132] [133] [135] [136] [137] [151] [162] [163] [164] [165] [169] [170] [171]

Project name: **DREAM –** DEVELOPMENT OF A "SEMI-DEEP" ROV FOR SCIENTIFIC APPLICATIONS AND ENVIRONMENTAL MONITORING.

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

Project Coordinator: ISR

Project Description: The objective of the present project is the development of a **Remotely Operated Vehicle** capable of "semi-deep" intervention (down to the 1000m range) to be used by the Portuguese scientific community in a variety of ocean research missions. Such a vehicle will allow for the investigation of a group of poorly known environments, including the Portuguese continental shelf, where the large majority of national fisheries are deployed, and the upper "levels" of the different canyons that cut into the Portuguese platform and that condition the Portuguese bathial environments to a high extent. "Off the shelf" vehicles can be found, capable of operating down to the proposed depth range, but none with the type of specifications needed for **environmental observation** and **monitoring**, namely in what relates to accurate positioning and work capacity – sensors and probe installation, sampling gear, video signal processing, etc.

The key technical contribution of the project is the enhancement of a basic ROV structure to enable precise vehicle navigation, guidance, and control as well as acoustic and vision data acquisition, pre-processing, and transmission to a support ship. This will enable maneuvering the ROV along pre-determined searching paths without tight human supervision. Furthermore, it will endow scientific end-users with the capability to survey the ocean floor with great precision by acquiring, among other, side-scan, video, and photo images that are accurately time and position tagged, allowing for mapping of the sea-floor. The user is thus relieved from the tedious and often unsuccessful task of trying to achieve precise vehicle control, namely in the presence of sea currents, effectively shifting the focus of the whole operation to scientific data assessment and overall mission control.

Another objective of the project is the possibility of applying a new concept by developing a "modular" vehicle, capable of being reconfigured for different purposes and mission scenarios. Indeed, no vehicle will meet directly the need of different "configuration" levels, enabling its use from different vessels and at a variety of depth ranges – from "shallow" intervention (c.a. 400m) onboard light vessels of "opportunity" to "deep" diving (down to c.a. 1000m) from a dedicated ship – and a quick "response time" to solicitations such as unpredictable environmental phenomena (e.g. submarine eruptions, spills or other accidents).

The proposing team brings together to the core of the project complementary expertises:

- the technical competence to develop such a vehicle from a brand system (ISR-IST);
- the experience of operation of ROV´s in the Portuguese environments (IMAR-LMG, CREMINER);
- and the capacity to operate the vehicle at sea under a wide range of different conditions (IH).

This is an important step in the development of collaborative ventures between science and technology, where either of the two components directly depends on the contribution from the other. The concept also opens the possibility of addressing specific needs of end-users, including social concerns, namely relating to natural resources management. Finally, the proposal includes the execution of specific surveys at sea. This will allow for the actual testing and demonstration of the vehicle capacities, both in its original configuration and after project development.

Research Areas: Marine Habitat Mapping Techniques
Laboratories: Dynamical Systems and Ocean Robotics Lab (DSORL)
External Partners: IMAR and Department of Oceanography and Fisheries, Univ. Azores, IGM – Geological Survey of Portugal.
Initiated: December 2000
Conclusion : December 2003
Classification*:* PDCTM, FCT (PT)
Documents produced in 2001: [101] [132] [136] [137] [163] [164] [165] [169] [170] [171]

Project name: **SUMARE –** SURVEY OF MARINE RESOURCES

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

Project description: The goal of SUMARE is to prove the utility of autonomous sensors for environmental monitoring, showing their efficiency in providing to the competent authorities the data required to guarantee a safe and sustainable exploitation of natural resources. Besides obvious savings in terms of time and costs associated with the use of oceanographic ships, autonomous sensors offer the possibility of :

(i) adaptively selecting the regions to be sampled in response to observed data;
(ii) exploiting the morphological characteristics of the sampled field to improve accuracy and consistency.

The project's work program assesses the multi-disciplinary issues underlying these goals: environmental knowledge modelling, data fusion, sensing and guidance. Its results will be tested in two marine applications :

(i) monitoring of the evolution of sand banks and
(ii) mapping of living/dead maerl.

The work program of the project is articulated around the main issues contributing to the design, implementation and use of autonomous intelligent sensors for monitoring applications. Use of existing knowledge concerning the macroscopic behaviour and physical constraints of a natural field can considerably increase data gathering efficiency, by enabling, in real-time, to use the measurements already acquired (or those of correlated parameters) to predict the most interesting or informative regions. For each application considered in the project, existing data, physical models and heuristic rules, will be used to identify mathematical prediction and extrapolation models for real-time guidance of the sensors. Moreover, monitoring efficiency is also increased by concentrating resources on optimising those performance indexes that reflect the actual needs of the post-processing stages of the acquired data. The project will study the problem of translating specific user needs in performance criteria and associated observation strategies, with the following guideline: data does not need to be better than the requirements imposed by its ultimate utilisation. To effectively use prior knowledge while optimising relevant performance criteria, the sensors must have sensing modalities and guidance laws enabling on-line execution of adaptive observation strategies. The project will develop the advanced sensing and guidance techniques required by the two kinds of applications considered.

Two true-size at-sea data acquisition campaigns will be used to evaluate the project's results in terms of facility of deployment, efficiency, accuracy, and cost. These campaigns will be conducted using two underwater platforms already existing in participating laboratories modified to fit their needs. The association to the consortium of a User Group, whose role is to follow its developments will provide critical input in terms of other application domains.

Research Areas: Signal Processing, Navigation, Computer Vision
Laboratories: Signal and Image Processing Lab, Vislab - Computer Vision Lab
External Partners: Management Unit of the North Sea Mathematical Models (B), International Centre for Island Technology – Heriot-Watt University (UK), I3S (Laboratoire *d'Informatique, Signaux e Systèmes de Sophia Antipolis* – CNRS- Université de Nice Sophia Antipolis) (FR), Thomson Sintra ASM (FR).
Initiated: 2000
Expected conclusion: 2002
Classification: IST Project , IST-1999-10836
Documents produced in 2001:

3.1.3 COOPERATIVE ROBOTICS

Project name: **SocRob –** Society of Cooperative Robots

Project leaders: Prof. Pedro Lima, Prof. Luis Custódio (AIMS Lab)

Project description: This project fosters general research on multi-agent robotic systems, aiming at introducing methodologies for task planning, task allocation and teamwork supervision/coordination, driven by results from Distributed AI, Hybrid Systems and Discrete Event Systems theory. Its current case study is on Soccer Robots, with regular participations in RoboCup.

Research Areas: Cooperative Robotics, Sensor Fusion, Multi-Agent Systems, Teamwork, Discrete Event Systems.
Laboratories: Intelligent Control Lab, Artificial Intelligence and Manufacturing Systems Lab
External Partners: FCT, ALCATEL, CGD, FLAD, ICEP Portugal, Philips Portuguesa.
Initiated: January 1997
Expected Conclusion:
Classification:
Documents produced in 2001: [15] [24] [25] [26] [27] [56].
Prototypes :

♦

Project name: **COOPERA** - COOPERATION AMONG MULTIPLE ROBOTIC DEVICES

Project leader: Prof[a] Maria Isabel Ribeiro (IST/ISR)

Project description: This project aims at developing and testing an architecture for cooperation among multiple robotic devices acting in cooperation in complex, dangerous, or not accessible environments. A mobile platform with a manipulator mounted on top of it is an example of two combined robotic devices. During the execution of some tasks it is necessary to establish cooperation between them in order to deal the existing constraints, e.g., the physical connection.

A population of several of these combined devices may also be pointed out as an example where cooperation may emerge. Consider, for instance, the transportation of an object of large dimensions by multiple mobile manipulators, acting in cooperation. For simple robotic devices, i.e., devices with a small number of degrees of freedom (dof), design methodologies for global task controllers are known. Systems with multiple robots may be considered as a single robot with multiple dofs. The immediate extension of these methodologies for robotic devices with a large number of degrees of freedom leads to a rapid increase in the computational complexity of the algorithms, making them useless for real time applications.

This project addresses the latter problem by developing an architecture where, instead of dealing with the overall system as a whole, a decoupling methodology supports the cooperation, i.e., the information interchange among the various robots. The architecture to be developed leads to a cooperative behaviour among a set of robots working towards a common goal and is modular, in the sense that it supports, with no major changes, any number of devices. Also, the decision mechanism under the architecture will be carried out at the level of each device, avoiding centralized decision making modules. The architecture is supported by a separation principle between the controllability properties of each robot, considered as an isolated entity, and those of the global system. Non linear control theory leads a major role in this area. The addressed problem is relevant because task execution in large workspaces often require robotic mechanisms combining locomotion and manipulation capabilities. In addition, complex tasks or tasks executed in complex environments may determine that more than one robotic device work together, in cooperation, to fulfill the task.

This application, points out two major advantages in the use of multiple robotic devices over the single robotic devices: simultaneous cover of a larger workspace area, and redundancy, making multiple robot systems robust to device failures and environment uncertainties.

Research Areas: Cooperation of robotic devices
Laboratories: Mobile Robotics Lab
External Partners:
Initiated: February 1997
Conclusion: December 2001
Classification: PRAXIS 2/2.1/TPAR/2087/95
Documents produced in 2001: [75]

♦

Project name: **RESCUE –** Cooperative Navigation for Rescue robots

Project leader: Prof. Pedro Lima (CI lab - IST/ISR)

AIMSlab involvement: Prof. Luis Custódio, Rodrigo Ventura

Project description: This project will endow a team of outdoors robots with cooperative navigation capabilities, so as to demonstrate the ability of the robots to act individually and cooperatively in search and rescue-like operation scenarios. Search and Rescue (SAR) operations are a challenging application for Robotics since, due to their nature, they naturally foster advances in Artificial Vision, Navigation in outdoors-unstructured environments, Distributed Artificial Intelligence and Intelligent Control.

The long-term objectives of the project consist of applications to SAR under large-scale catastrophe scenarios, namely after an earthquake. However, the current proposal is focused on the first steps towards the long-term goal and, as such, it refers to simpler scenarios and is based on some simplifying hypotheses, such as daylight operation and pre-planned robotic tasks. Also, the robotic team will include only 2 robots, purposively made heterogeneous, both regarding the functional, hardware and software architectures: one wheeled and one-legged mobile robot. Wheeled robots are generally faster and have a payload larger than legged robots. Nevertheless, the latter have greater mobility within SAR scenarios. Therefore, each type of robot can be assigned tasks with different requirements under SAR operations.

Research Areas: Cooperative Robotics (for outdoors)
Laboratories: Intelligent Control Lab, Artificial Intelligence and Manufacturing Systems Lab, Computer Vision Lab, Mobile Robotics Lab
Initiated: Jun. 2000
Expected conclusion: May 2003
Classification: POSI/33293/SRI/2000
Documents produced in 2001: [52]

3.1.4 LAND MOBILE ROBOTICS

Project name: **RODITAS III –** Robô Didáctico para Técnicos de Automação de Sistemas

Project leaders: Prof. Pedro Lima

Project description: This is an educational project aiming at promoting the experimental teaching of science and technology at high schools. The students learn electronics and mechanics while building a small LEGO robot.

Research Areas: N/A
Laboratories: Intelligent Control Lab
External Partners: INETE – Instituto de Educação Técnica (Technical High School)
Initiated: January 2001
Expected Conclusion: July 2002
Classification: Unidade Ciência Viva
Documents produced in 2001:
Prototypes :

3.1.5 ROBOTIC MANIPULATION

Project name: Open Distributed Control Architecture for a **PUMA 560** Manipulator

Project leaders: Prof. Pedro Lima

Project description: Within the scope of this project, an open control architecture for a PUMA 560 is being developed. The current status of the project allows distributed control of the arm, based on a local Ethernet PC network. A central node runs, under Windows 98, a *Petri net executor* that supervises task execution. Other nodes are now ready to run *primitive task servers* under Linux. Communication is supported on the TCP/IP protocol.

Research Areas: Discrete Event Systems, Petri net Models of Robotic Tasks, Task Supervision under partial and/or noisy information.
Laboratories: Intelligent Control Lab
External Partners:
Initiated: October 1994
Expected Conclusion:
Classification: ISR/IST funding
Documents produced in 2001: [60]

3.1.6 IMAGE PROCESSING

Project name: **TMO** - Tracking of Moving Objects with Trained Multi-Models

Project Leader within ISR: Prof. Jorge Salvador Marques

Project description: This project aims at developing robust tracking algorithms for dealing with complex motion and shape dynamics. Current methods achieve good tracking performance in the presence of non-cluttered background and smooth motion and deformation regimes but they typically loose track if one of these conditions fails. This project studies the use of multiple deformable models with switching/mixing algorithms as a way to enlarge the tracking capabilities. This raises several interesting questions: how to combine multiple models or switch between them? Can tracking be improved if the parameters lie on manifold contained in R^n? What methods can be used to estimate the manifold and the parameter trajectory? Other topics that will be addressed in this project are multi-model learning and robust trajectory estimation methods to reduce the influence of outliers. The proposed algorithms will be tested in selected applications.

Research Areas: Image Processing
Laboratories: Signal Processing Lab.
External Partners: IST, ISEL
Initiated: 1999
Expected conclusion: 2001
Classification: PRAXIS/P/EEI/12050/1998
Documents produced in 2001: [39] [109] [110] [111] [112] [152] [154]

♦

Project name: Automatic Classification of Marble Tiles – **CVAM**

Project Leader within ISR: Prof. Jorge Salvador Marques

Project description: This projects aims to develop methods for automatic classification of marble tiles. Presently, there are no standard criteria to classify marble tiles. Each tile is manually inspected and compared with other based on subjective evaluation. Furthermore, the subjective inspection rules changes depend on the factory that produces the tiles. The goal of this project is the choice of a set of visual features useful for the inspection of marble tiles and the development of classification methodologies. The results will be compared with the opinion of several experts in order to characterize the differences. The main difficulty of this problem lies on the fact that the optimal classification is not known in this problem.

Research Areas: Image Processing
Laboratories: Signal Processing Lab.
External Partners: IST, INESC, INETI
Initiated: 1999
Expected conclusion: 2001
Classification: PRAXIS/2/2.1/TPAR/2057/95
Documents produced in 2001:

Project name: **HEART 3D** - Measurement of the Heart Geometry from Ultrasound Images

Project Leader within ISR: Prof. Jorge Salvador Marques (IST/ISR)

Project Description:
This project studies heart diagnosis tools based on 3D ultrasound techniques. The project has three main goals: i) the development of image reconstruction and heart measurement algorithms for the analysis of the cardiac cycle and computation of clinical parameters (ventricular volume, ejection fraction and wall thickness)); ii) implementation of an experimental set up for the acquisition of 3D data during medical examinations of the heart and iii) clinical evaluation of the 3D ultrasound algorithms developped in the project.Bayesian reconstruction methods will be used to estimate a 3D+T model of the heart at different instants of the cardiac cycle. The region of interest will be described using a multi-scale representation based on 3D splines. The motion and deformation of the heart cavities will be obtained by segmenting the reconstructed volume at each instant of time. To fill the gaps between the inspection planes some kind of interpolation has to be devised. This operation is embodied in the Bayesian reconstruction provided that an adequate prior is used. Unfortunately popular Gaussian priors have an undesirable smoothing effect at the boundaries which degrades the estimation of the heart walls. Therefore, a discontinuity preserving prior will be used instead.Another key aspect for achieving high quality results concerns the data model used for reconstruction.

Research Areas: medical imaging, image processing, image reconstruction, noise removal
Laboratories: Signal Processing Lab.
External Partners: Cardiology Department of Hospital de Santa Maria, University of Aveiro
Initiated: 2000
Conclusion : 2003
Classification: POSI/33726/CPS/2000
Documents produced in 2001: [108] [113] [153]

3.1.7 UNDERWATER ACOUSTICS

Project name: CARACTERIZAÇÃO ESPECTRAL DE EFEITOS ACÚSTICOS EM AMBIENTE **MARINHO**

Project Leader: Prof. Victor Barroso (IST/ISR)

Project description: This project aims to define spectral descriptions, identifying invariant features to characterize some underwater acoustic effects. These descriptions must be substantially reliable so as to enable the automatic classification of those acoustic effects.

Research Areas: Time - Frequency Signal Analysis
Laboratories: Signal Processing
External Partners: Escola Naval (Portuguese Navy School)
Initiated: 1999
Conclusion: November 2001
Classification: Min. da Defesa Nacional - Fundação das Universidades Portuguesas
Documents produced in 2001:

Project name: DETECTION AND FUZZY CLASSIFICATION OF **TRANS**IENT SIGNALS IN THE TIME - FREQUENCY PLANE

Project Leader: Prof. Victor Barroso (IST/ISR)

Project description: New techniques for passive detection and classification of underwater acoustic transient signals are developed and tested. The focus is on theoretical and algorithmic aspects so as to achieve an acceptable compromise between optimality and robustness to model mismatches, and computational efficiency. Several classes of transients are considered, e.g., man made, mammals' signatures, and spiky noise generated by hydrothermal vents, covering a diversity of frequency bands and physically appropriate source models (deterministic and stochastic). The methods here proposed match the temporal non-stationarity of transient signals. Observation noise is assumed either Gaussian or non-Gaussian impulvive.

Data representation involves filtering and sampling the received signal, followed by a linear decomposition using the discrete wavelet transform with compactly supported short duration filters. Assuming that a delayed signal is correctly represented by its delayed coefficients, the process described is optimized, yielding the best compromise between performance and computational complexity. This implies choosing the observation intervals, the sampling frequencies, the likelihood test rates for real-time processing, and the design of the mother wavelets. Suboptimum processors are also developped for multipath ambients, assuming random multipath attenuations and delays. The proposed approach can increase the robustness of the resulting detector, requiring much less computations than the generalized likelihood ratio test.

Translating classical detection techniques to the Time-Frequency (TF) plane does not produce better detection statistics. However, working in the TF plane provides a significant advantage: more powerful pre and post processing allow operation in lower SNR's (<-5 dB). By adjusting the TF kernel, distinct suboptimal detectors result and the best suited for each specific transient can be selected. Additional complexity, due to bidimensional correlation, is combated using a generalised distribution, representing the transient as a delta distribution. This square roots the computational cost. The design of that distribution, being trivial for polynomial phase signals, is generalised to accommodate the transients considered.

The performance of the proposed techniques is evaluated based on the theoretical analysis of the algorithms developed and/or on computer experiments driven by simulated and real data.

Research Areas: Statistical Signal Processing
Laboratories: Signal Processing
External Partners: Escola Naval (Portuguese Navy School)
Initiated: 2000
Conclusion: September 2003
Classification: POSI/32708/CPS/2000
Documents produced in 2001:

♦

Project name: CHANNEL ESTIMATION FOR EQUALIZATION AND SYNCHRONIZATION IN **OFDM** UNDERWATER ACOUSTIC COMMUNICATION SYSTEMS

Project Leader: Prof. Victor Barroso (IST/ISR)

Project description: Digital communication using acoustic modems is the method of choice for exchanging data among distant or highly mobile equipment used in various underwater activities. However, achieving efficient communication in this environment is challenging due to severe distortions that affect the transmitted signals as they undergo multiple reflections and refractions in their propagation path. Attempts to overcome these impairments in high data rate coherent modems haven't been entirely satisfactory, thus hampering their widespread adoption.

Recently, much attention has been devoted to the use of OFDM (Orthogonal Frequency Division Multiplexing) modulation for wireless and cable applications as a way of approaching channel capacity with simple transmitter/receiver architectures. In OFDM the message stream is divided into many parallel lower rate streams that modulate a set of partially overlapping orthogonal carriers. Since longer symbols are less sensitive to multipath, equalization requirements may be considerably relaxed on each subcarrier. This feature is quite appealing in underwater communications, where highly complex filters used for equalization constitute the main computational bottleneck.
Although preliminary studies on the use of OFDM for underwater coherent communication have been published, the analyses are rather superficial and should mainly be regarded as proof of concept. The present proposal will address issues that are particularly relevant in an underwater environment:

1- Channel identification and equalization are extremely important in underwater communication because multipath propagation may induce channel responses lasting hundreds of milliseconds. Unlike terrestrial OFDM applications, frequency-selective channels have to be explicitly considered. Recently developed blind or semi-blind identification techniques should be applicable under such conditions, thus reducing the need for pilot tones.

2- Significant Doppler shift may be induced in acoustic waveforms even by relatively slow emitter/transmitter motion caused by waves and currents. Performance studies for terrestrial OFDM have shown that accurate tracking of average Doppler is required to ensure low intercarrier interference. Average and differential Doppler compensation has not been studied in detail for single-carrier communications, but it will likely play an important role in underwater OFDM systems. An approach based on simple ray propagation models will be used to predict the evolution of Doppler in each path and guide the tracking algorithms.

Research Areas: Statistical Signal Processing
Laboratories: Signal Processing
External Partners:
Initiated: 2000
Conclusion: September 2003
Classification: POSI/33205/CPS/2000
Documents produced in 2001:

3.1.8 COMPUTER VISION

Project name: **OMNIVIEWS –** OMNIDIRECTIONAL VISION SYSTEM

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

Project description: The goal of the project is to integrate optical, optoelectronic, hardware, and software technology to realise a smart visual sensor, and to demonstrate its utility in key application areas. In particular our intention is to design and realise a low-cost, miniaturised digital camera acquiring panoramic (360 deg) images and performing a useful low-level processing on the incoming stream of images in real-time. Target applications include surveillance, quality control and mobile robot and vehicle navigation.

Research Areas: Computer Vision
Laboratories: Vislab - Computer Vision Lab
External Partners: DIST - University of Genova (I), Czech Technical University (Cz).
Initiated: September 2000
Expected conclusion: September 2001
Classification: IST-Proj. 1999-29017
Documents produced in 2001: [70] [71] [72] [76] [78]

Project name: **SIVA –** INTEGRATED SYSTEM FOR ACTIVE SURVEILLANCE

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

Project description: With this project we aim to develop an autonomous system able to perform surveillance tasks in a structured environment. The system as a whole will be made up of several mobile platforms ("agents"). Each of them will be equipped with an active vision system, an odometry system and communication links enabling the platforms to communicate among themselves. As a whole the full system (including all the platforms) will have a high degree of autonomy. Each of the platforms will also be autonomous in terms of the navigation and surveillance tasks. The system will be designed to operate off-hours in structured environments such as supermarkets, military installations, public buildings, power plants, etc.. The implication of its use during off-hours is that the primary condition for the detection of an intruder will be the occurrence of motion. Each one of the "agents" will perform the surveillance tasks based on the active vision system. Navigation will also be performed based on the active vision system and on the odometry system. The environment map will be known "a priori" and landmarks both natural and artificial will be used for localization. Both navigation and surveillance do not have to be performed with accuracy. Indeed each "agent" will only be concerned with not repeating its trajectory so that all the map area is covered periodically. Agents will have to cooperate so that they do not survey the same area simultaneously. Therefore there will be communication links enabling the "agents" to inform one another from their activities. Cooperation will occur at several levels namely to ensure that the "agents" survey different areas, to avoid collisions and to enable the execution of common taks such as pursuing an intruder.
We propose to demonstrate this system by using two mobile and active "agents" that cooperate in a structured environment.

Research Areas: Computer Vision, Mobile Robotics
Laboratories: VisLab – Computer Vision Lab
External Partners: ISR – Coimbra Pole
Initiated: Jan. 1998
Expected conclusion: April 2001
Classification: PRAXIS 2/2.1/TPAR/2074/95
Documents produced in 2001:

♦

Project name: **MIRROR –** Mirror Neurons for Recognition

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

Project description: The goals of MIRROR are:

1) to realize an artificial system that learns to communicate with humans by means of body gestures and
2) to study the mechanisms used by the brain to learn and represent gestures.

The biological base is the existence in primates's premotor cortex of a motor resonant system, called mirror neurons, activated both during execution of goal directed actions and during observation of similar actions performed by others. This unified representation may subserve the learning of goal directed actions during development and the recognition of motor acts, when visually perceived. In MIRROR we investigate this ontogenetic pathway in two ways:

1) by realizing a system that learns to move AND to understand movements on the basis of the visually perceived motion and the associated motor commands
and
2) by correlated electrophysiological experiments.

Research Areas: Computer Vision
Laboratories: Vislab - Computer Vision Lab
External Partners: DIST - University of Genova (I), University of Ferrara (I), Dept. of Psychology Univ. of Umea, (SE)
Initiated: September 2001
Expected conclusion: March 2004
Classification: EU - FET - 2000-28159
Documents produced in 2001:

♦

Project name: **3D** MODELING FROM VIDEO

Project leader within ISR: João Paulo Salgado Arriscado Costeira

Project description: This project proposes to develop a methodology for video coding by using intermediate 3D representations. The coded video includes a representation of the scene's 3D shape and texture, producing as output a sequence of synthetic views of the scene (which could be different from the original ones). This opens new perspectives to go one step forward towards general content-based video representations.
There are three main issues involved which we propose to tackle:

1 - Image to image matching,
2 - Image to model matching and
3 - 3D model building and generation of images from the 3D model.

Past research experience within our groups include, not only the ability to compute 3D shape under the orthographic viewing model, but also dealing with artifacts like multiple moving objects, occlusions, inclusion of new features and fast rank 1 factorization of planar surface patches.Very recent developments have shown that it is possible to formalize the matching process in a global analytical fashion with outlier rejection at the same time. This approach suggests the possibility of integrating, within a single optimization framework,a both image to image and image to model matching. By doing this we introduce feedback into the matching process. In other words, we propose to guide the matching process using previously computed 3D shape and texture in a recursive way, dealing with occlusion and inclusion of new objects at the same time.
This concept is a keystone in the whole project since it makes possible finding image to model and image to image matching without tracking individual points between consecutive images. The bottom line is an optimization procedure that globally finds image points that are represented in the model, rejecting the outliers. These outliers are either occlusions, points not represented in the model or unreliable measurements which can be used to update the 3D model. Another important issue is the 3D shape and texture reconstruction and video rendering. Again, past experience provides some cues, in particular in the potential shape reconstruction using planar patches for which we know a fast factorization method and image generation using octreed in 3D data. The challenge is to build efficient shape and texture (image) representations to accommodate the matching. In other words to feed this global representation back into the matching process, turning the motion an implicit parameter which need not be computed. In terms of shape recovery this may be possible, for now, due to the scaled orthographic (or affine) camera model since most constraints resume to finding the match that satisfies some rank constraints. Under full perspective the computations are a lot more complex since at some point we need to know explicitly the calibration parameters. However we foresee a more or less straightforward extension to piecewise planar scenes which can be described by a homography. On the decoder side, fast algorithms based on octrees for 3D representations will be developed for fast video generation from the shape and texture (compact) representation.

Research Areas: 3D reconstruction, Video Coding, Structure from motion, Computer vision
Laboratories: Vislab - Computer Vision Lab, Signal and Image Processing Lab.
Initiated: October 2000
Expected conclusion: 2003
Classification: POSI/34121/SRI/2000
Documents produced in 2001:

3.1.9 3D ENVIRONMENT RECONSTRUCTION

Project name: **CAMERA** - CAD MODELLING OF BUILT ENVIRONMENTS FROM RANGE ANALYSIS

Project leaders within ISR: Prof. Maria Isabel Ribeiro, Prof. José Santos-Victor (IST/ISR)

Project description: The scientific objectives of the network are to investigate:

- methods for construction of finite and unbounded (ie. Without the natural closure of individual objects) CAD models of built environments including both interiors and exteriors.
- methods for extraction and incremental fusion of typical environmental features (eg. pipes, walls, floors).
- how to fuse sparse, but continuously tracked shape, obtained from projective geometrical analysis of intensity images with dense shape obtained from single range images.
- how to plan for incremental sensing for extending and filling out models.
- how to exploit constraints typical of built environments (eg. systematic rectangularity and parallel features) or typical architectural structures (eg. doorways) to improve model accuracy.
- how to link locally accurate models (eg. of individual rooms) to form accurate global descriptions of the environment (eg. by exploiting constraints arising from two rooms being adjacent across a wall).
- how modules implementing the research results might be integrated together in a usable system.

The training objectives of the project are:

1- develop cross-disciplinary skills in computer vision, computer graphics, computer-aided design, sensor navigation and fusion and photogrammetry.

2- provide post-doctoral researchers with broader project perspectives, trans-national experience and experience in a commercial organisation.

3- provide a forum for idea exchange and accelerated progress in a new and rapidly developing research area. Within CAMERA, ISR/IST main interests are on the areas of range data acquisition, 3D reconstruction based on range and/or visual data, integration of multisensory range information, perception planning and execution, control of data acquisition, camera tracking, reverse engineering.

Research Areas: 3D Environment Reconstruiction, CAD Modelling, Perception
Laboratories: Computer Vision Lab, Mobile Robotics Lab
External Partners: University of Edinburgh – project leader (UK), Royal Institute of Technology (S), Joint Research Centre (I), UK Robotics (UK), LAAS-CNRS(F), Fraunhofer Institute (G).
Initiated: January 1998
Conclusion: December 2001
Classification: TMR (Training and Mobility of Researchers) ERB FMRX CT970127, EU
Documents produced in 2001:

3.1.10 ARTIFICIAL INTELLIGENCE

Project name: **MS-AGENCY:** Control of Manufacturing Systems using Societies of Evolutive Agents

Project leader: Prof. Luis Custódio (IST/ISR)

Project description: In this project, the problems raised by the development, utilization and implementation of both hierarchical and heterarchical control architectures for manufacturing systems (MS) are studied and identified. The goal is to develop a hybrid control architecture where the lower levels are implemented through a heterarchical structure, using a new paradigm of distributed (knowledge) representation called "Societies of Agents". The upper levels are structured into a hierarchy where the top levels provide orders for bottom levels, as usual. A liaison agent called "majordomo" performs the connection between hierarchical part of the architecture and the heterarchical one. In terms of equipment and layout it is assumed that the shop-floor is (physical or virtually) divided into a set of manufacturing cells, each one capable of producing a predefined set of products. Each cell is represented by a single agent, which is capable of interacting within a society of similar agents. Based on a production plan created on the hierarchical layer the "majordomo" agent initiates a process of negotiation among all cell representative agents. After the negotiation process is over, the control of the production is passed for each manufacturing cell controller, which will be based on fuzzy control using a previously proposed structure.

Research Areas: Artificial Intelligence, Multi-agent Systems, Manufacturing Systems Control
Laboratories: Artificial Intelligence and Manufacturing Systems Lab
Initiated: 1999
Expected conclusion: December 2002
Classification: Project nº PRAXIS/C/EEI/12175/1998
Documents produced in 2001:

♦

Project name: **DARE –** Study of Methodologies for the Development of Emotion-based Robotic Agents

Project leader: Prof. Luis Custódio (IST/ISR)

Project description: The aim of this project is the study and development of methodologies and tools necessary to implement emotional robotics agents capable of dealing with unstructured, complex environments. Therefore, the goal is not to try optimize some particular ability, but instead the interest is put on general competence to learn, adapt itself and survive. In order to practically test these ideas, a small autonomous robot will be constructed using technology already developed and tested.

Research Areas: Artificial Intelligence, Emotion-based Agents
Laboratories: Artificial Intelligence and Manufacturing Systems Lab (coordinator), Intelligent Control Lab
Initiated: 1999
Expected conclusion: December 2002
Classification: Project nº PRAXIS/C/EEI/12184/1998
Documents produced in 2001:

♦

Project name: **SIPOGE –** Planning of emergency activities and optimization of resources allocation

Project leader within ISR: Prof. Luis Custódio (IST/ISR)

Project description: The ability for managing correctly emergency situations is a vital need for any entity, like a business firm, a big installation, as an airport, a power station, a natural gas network, a refinery, but specially important for a Civil Protection structure, at different geographical levels. This management should take into account not only the existence of adequate emergency plans, but also the mechanisms needed for optimizing the plan execution, including the correct utilization of available resources, according the emergency situation diversity and dynamics.

This project aims at the study and development of an adequate methodology for optimizing emergency plans, that would be domain independent and would allow a dynamic management of different situations. As a case study, this methodology will be tested using the emergency plans of the Portuguese Civil Protection Service, for two different situations: earthquakes and floods in Tagus river.

Research Areas: Artificial Intelligence
Laboratories: Artificial Intelligence and Manufacturing Systems Lab
External Partners: National Service for Citizen Protection, University of Evora, Portugal Heuristica
Initiated:
Expected conclusion:
Classification: Submitted to the Agency for Innovation (ADI) , 2001
Documents produced in 2001:

3.1.11 BIOMEDICAL ENGINEERING

Project name: **CORTEX:** A SYSTEM FOR LEARNING AND RECOGNITION OF VISUAL OBJECTS

Project leader: Prof. Agostinho C. Rosa (IST/ISR)

Project description: This project's goal is to create a model of the object recognition system in the Visual Cortex. Once it is finished, the model is intended to either acquire new object concepts or to recognize previously encountered objects. In the latter case, the model will be able to pin point an object as being "recognized", and the neural network will behave in a way similar to what has been experimentally observed in the identification systems of primates and humans. Namely, the triggering synchronization of neurons that is associated with the sight of the same object.

Research Areas: Image Representation and Object Recognition
Laboratories: Evolutionary Systems and Biomedical Engineering Lab.
External Partners:
Initiated: JAN 2001
Expected Conclusion: DEC 2001
Classification: POSI/34606/SRI/2000
Documents produced in 2001:

3.1.12 OPERATIONS MANAGEMENT

Project name: **ESCALÃO** - INVENTORY CONTROL IN SUPPLY CHAINS

Project leader: Prof. Carlos Bispo (IST/ISR)

Project description: Study of optimal and sub-optimal production control policies for simple supply chains (less than 5 stages). Each stage has random capacity (due to failures and random yield) and are subject to material random demand.

Research Areas: Stochastic control
Laboratories:
External Partners:
Initiated: 1998
Expected Conclusion:
Classification: Internal project
Documents produced in 2001: [9] [31] [83] [84] [85]

3.1.13 DATA NETWORKS

Project name: **DiSNet –** Distributed Scheduling for Networks

Project leader: Prof. Carlos Bispo (IST/ISR)

Project description: To develop local scheduling policies for systems modelled by networks of queues, as is the case of manufacturing systems and data transmission networks. It is aimed at defining a super-class of local scheduling policies which contains non work-conserving and work-conserving policies as sub-classes. The main issue to address is to obtain a set of provably stable policies for networks where the traffic condition holds.

Research Areas: Queuing Networks and Stochastic Optimization
Laboratories:
External Partners: Instituto das Telecomunicações at IST
Initiated: 2001
Classification: POSI/34646/SRI/2000
Documents Produced in 2001: [10] [122]

3.1.14 COMUNICATIONS

Project name: SEPARATION OF DIGITAL SOURCES' MIXTURES BY **CONVEX** METHODS

Project leader: Prof. João Sentieiro

Project description: The main objective is to design a spatial division multiple access (SDMA) receiver, which permits to blindly resolve a convolute mixture of digital sources. An existing convex geometrical framework for binary sources is to be extended in order to incorporate in the receiver the following features:

(a) robustness to the channel order detection step. By (possibly) avoiding the estimation of the orders of the space-time channels activated by the sources, the receiver will outperform (in terms of robustness) most of the current approaches, whose performance is known to depend crucially on the accuracy of theses estimates - specially for band limited channels whose impulse response exhibits smooth roll offs making the channel length ill-defined. To meet this requirement, the linear equalizers have to be characterized directly in the observation space, which poses new theoretical challenges;

(b) ability to cope with more generic digital modulation alphabets, e.g, PAM,QAM,PSK, etc;

(c) increased robustness with respect to the noise power, which implies the formulation of new convex (or quasi-convex) problems in the "least-squares" sense.

Research areas: Mobile Wireless Communications
Laboratories: Signal Processing Lab, Theory Group
External partners:
Initiated: October 2000
Expected conclusion: October 2003
Classification: POSI/32948/CPS/2000
Documents produced in 2001:

3.1.15 AERONAUTICS

Project name: VELA – Very Efficient Large Aircraft

Project leader: Prof. Luis Braga Campos

Project description: Assignment of stability of flying using a Aircraft

Research Areas: Aircraft design, airplane
Laboratories: Aeronautics Group
External Partners: 20 partners
Initiated: 2002
Expected conclusion: 2004
Classification: EU – Industrial Research
Documents Produced in 2001:

Project name: ROSAS – Research on Silent Aircraft Concepts

Project leader: Prof. Luis Braga Campos

Project description:

Research Areas: Acoustics, Engine noise, Diffractions
Laboratories: Aeronautics Group
External Partners: 18 partners
Initiated: 2002
Expected conclusion: 2004
Classification: EU – Industrial Research
Documents Produced in 2001:

♦

Project name: SILENCER – Significantly Lowe Communications Enounce to Noise Reduction

Project leader: Prof. Luis Braga Campos

Project description:

Research Areas: Acoustics, Engine noise
Laboratories: Aeronautics Group
External Partners: 90 partners
Initiated: 2002
Expected conclusion: 2005
Classification: EU – Industrial Research
Documents Produced in 2001:

♦

Project name: ENABLE – Environmental Noise Associated with Turbulent Boundary loge Excitation Dassault

Project leader: Prof. Luis Braga Campos

Project description:

Research Areas: Aeroacoustics, Aircraft design
Laboratories: Aeronautics Group
External Partners: 16 partners
Initiated: 2001
Expected conclusion: 2003
Classification: EU – Industrial Research
Documents Produced in 2001:

Project name: JEAN – Jet Engine Aerodynamics and Noise

Project leader: Prof. Luis Braga Campos

Project description: Research on the relation between the spectrum of turbulence and the spectrum it radiate and transmission of sound across a sheen lays

Research Areas: Acoustics, Aerodynamics, turbulence
Laboratories: Aeronautics Group
External Partners: 10 partners
Initiated: 2001
Expected conclusion: 2005
Classification: EU – Industrial Research
Documents Produced in 2001:

♦

Project name: S-WAKE – Assessment of Wave vortex safety

Project leader: Prof. Luis Braga Campos

Project description: Establishment of analytical formula to predict safe separation distance between aircraft , based on aerodynamic.

Research Areas: Flight Dynamics, aircraft management , Airplane response
Laboratories: Aeronautics Group
External Partners: 18 partners
Initiated: 2000
Expected conclusion: 2002
Classification: EU – Industrial Research
Documents Produced in 2001:

♦

Project name: X-Noise – Aircraft External Noise Network

Project leader: Prof. Luis Braga Campos

Project description: Research on all aspects of Aircraft external noise.

Research Areas: Aeroacustics, Aircraft Noise
Laboratories: Aeronautics Group
External Partners: 30 partners
Initiated: 2002
Expected conclusion: 2004
Classification: EU – Industrial Research
Documents Produced in 2001:

3.2 POST-DOCS ACTIVITIES REPORTS

3.2.1 ACTIVITY REPORT OF DIDIK SOETANTO

- **INTRODUCTION**

This report summarizes the research activities that I carried out in the period of June 2001-January 2002.

The research topics are selected to lay a ground work for the future work in designing a robust controller for the cooperation between AUV and ASV marine crafts. At the moment, the controllers are designed for wheeled mobile robots of the unicycle type with a nonholonomic constraint.

- **1 PATH FOLLOWING CONTROL OF A UNICYCLE**

The objective of this study is to design a nonlinear control law for a unicycle-type robot with a nonholonomic constraint to follow a prescribed path. The robot's states are expressed relatively to the path using Frenet frame. A controller is designed using Lyapunov method followed by a series of backstepping.to yield a locally asymptotically stable solution in the presence of parametric modelling uncertainty.

Result: A control method for a dynamical model of a unicycle, based on the controller for its kinematic model and backstepping method, is proposed. The convergence of the heading and distance to the path to zero was analyzed. The simulation results show that the objective goals were achieved successfully regardless of the presence of the parametric modelling uncertainties. At present, there is no known way to compute the exact bound on the amplitude of the jitters in the system response due to sensor noises. However, as shown in convergence analysis, the control law allows some noise to be present in the measurement while keeping the system stable. Another issue that needs to be investigated in the future is the effect of noise frequency to the system.

Publication:
Soetanto, D. J. and Pascoal, A. M., "Path-Following Control for a Nonholonomic Dynamic Mobile Robot with Parametric Modelling Uncertainties"
Status: Pending Prof. Pascoal's approval

- **2 MANOUVER MODIFIED TRAJECTORY TRACKING CONTROL OF A UNICYCLE**

The objective of this study is to design a unicycle-type robot with a nonholonomic constraint to follow and/or track a prescribed path. A controller is designed to yield a globally asymptotically stable solution with combined path following and trajectory tracking attributes in the presence of parametric modelling uncertainties. It is designed using input-output linearization method with backstepping technique and maneuver modified trajectory tracking method.

Result: A controller for a unicycle-type robot with its dynamics included in the model to follow a trajectory/maneuver is proposed. A kinematic controller for a unicycle-type mobild robot was modified using backstepping technique to incorporate the dynamical aspects. Then, a maneuver modified trajectory tracking controller with its ability to adapt to parametric modelling uncertainties was derived. The convergence to the maneuver and the convergence in time were analyzed. The simulation results show that the objective goals were achieved successfully regardless of the presence of the parametric modelling uncertainties. A downside to this method is the time it takes to compute the trajectory time, which often is done numerically since it may not be trivial to find its closed form solution depending on the shape of the trajectory/maneuver.

Publication:
Soetanto, D. J. and Pascoal, A. M., "Combination of Path Following and Trajectory Tracking Controls for a Unicycle-Type Wheeled Robot with Parametric Modelling Uncertainties"
Status: Pending Prof. Pascoal's approval

- **3 POINT STABILIZATION OF A UNICYCLE USING SATURATING ACTUATOR**

This study addresses the problem of controlling a nonholonomic wheeled mobile robot of a unicycle type to a desired position using bounded inputs. A controller that yields global asymptotic stability of the closed loop system is derived using Lyapunov method and backstepping method. Controller design is based on a class of saturation function. Convergence to the desired position under bounded inputs is analyzed.

Result: A control law for regulating a non-holonomic wheeled mobile robots of the unicycle type to a desired point P using saturating inputs was proposed. A non-smooth coordinate transformation was utilized to derive the control law. The velocity regulation was decoupled from the heading regulation, and each of the regulators was derived using Lyapunov method with the backstepping method. A set of saturation functions was used to satisty the input constraints. Convergence to P was analyzed and simulations were carried out to illustrate the performance of the controller design. Simulation results show that the control objectives were achieved successfully. Future research should look into the parameter adaptation as to make the control design robust against the model's parameter variations.

Publication:
Soetanto, D. J. and Pascoal, A. M., "Control of a Unicycle-Type Wheeled Mobile Robot with Saturating Actuators"
Status: Pending Prof. Pascoal's approval

- **4 COOPERATIVE CONTROL OF A GROUP OF UNICYCLES**

The objective of this study is to design a method for controlling a group of unicycles together. The problem is compounded by the absense of the velocity and acceleration information from the leader. Several control methods, which utilize the previous research topics, are being investigated.

Result: This study is still in progress. A preliminary analysis of the nonlinear control law being developed for the cooperation between 2 or more unicycles shows encouraging results. Further analysis and simulations from different methods are needed for the comparison and the investigation of the controller robustness.

Publication:
Soetanto, D. J. and Pascoal, A. M., "Cooperative Control of a Group of Unicycles" (tentative title)
Status: In progress

Lisboa, January 2002
Didik Soetanto, Ph.D.
Instituto de Sistemas e Robótica
Instituto Superior Técnico

3.2.2 ACTIVITY REPORT OF LIONEL LAPIERRE

I'm working on the Freesub project with the DSOR team, concerning the following topics :

i) global and local navigation algorithms,
ii) strategies for trajectory tracking, path following, and position control of marine robots.

One of the envisioned contributions of my implication in the Freesub project is the study and development of new methodologies for Navigation, Guidance, and Control of marine vehicles. The methodologies should afford system designers advanced tools for the design of NGC systems for a wide range of platforms. Stringent requirements on NGC system design were imposed by the need to:

i) obtain accurate estimates of a marine vehicles' position and attitude by fusing multi-rate, possibly asynchronous, sensor data with different latencies in the measurements,
ii) achieve good trajectory tracking or path following in the presence of hydrodynamic parameter uncertainty and unknown external disturbances (e.g. wind, currents, and waves in the case of an autonomous surface craft).
iii) achieve precise position control for an underactuated vehicle (e.g. steering an underwater vehicle without a side thruster to a desired target point), and

1. Global and Local Navigation

In the area of Global Navigation, work was carried out on the development of methodologies that explicitly address the time-varying, multi-rate characteristics of the problem at hand. The strategies adopted avoid the use of Extended Kalman filters since these lack stability guarantees. Instead, navigation system design is rooted in solid physical principles that lead to navigation architectures with guaranteed stability and performance. The new *complementary filter* structures have been fully tested at sea in the Azores for navigation of the DELFIM autonomous surface craft (ASC). In the configuration adopted, DELFIM was equipped with a DGPS unit, a Doppler log and an attitude reference unit. The methodologies developed will be tested later in the project on board the INFANTE AUV.

My work consists in the study of new nonlinear complementary filtering structures for the case where vision data are complemented with inertial sensor data, e.g. velocity with respect to the water. This study was motivated by the practical need to maneuver an AUV and an ASC in cooperation at close range, in waters with very good visibility (up to 30 meters). In this case, updates on the relative position of the AUV with respect to an ASC can be estimated from vision data acquired with a camera installed on-board the ASC. The general set-up adopted paves the way for the development of advanced navigation systems for underwater vehicles that explicitly complement vision data with that acquired with other sensor suites. Interestingly enough, by exploring the geometry of the problem, the navigation filter dynamics can be cast in the framework of linear parametrically varying systems (LPVs). Filter performance and stability can then be formally studied in an H_∞ setting by resorting to the theory of linear matrix inequalities. This is in striking contrast with Extended Kalman Filtering techniques which do not yield stability guarantees. The problem of filter stability in the case of temporary image loss is a topic of current research.

2. Trajectory Tracking, Path Following and Position Control of Marine Robots

From a control point of view, a camera can be seen as a non-linear sensor that provides accurate information on the position of a robot with respect to an observed feature. After the choice of the feature parameterization in the image, it is the goal of the control strategy to drive the feature parameters to desired values. Since the control is organized in the image plane, explicit estimation of the 3D position is not necessary, which relaxes the constraint of having to perform a camera calibration. Most vision based control schemes proposed in the literature ignore the dynamics of the plant being controlled. While this simplification may be warranted in the case of wheeled robots, this is not necessarily so for underwater robots. This is due to the fact that these vehicles may be quite sluggish and exhibit complex hydrodynamic characteristics. It is also interesting to point out that most results published in the literature show that vision based control schemes end up relying heavily on vision only, thus precluding the use of advanced control techniques that require fast access to velocity related state variables. A new nonlinear, adaptive, vision based control algorithm for path

following applications was developed that explicitly takes into account vehicle dynamics and parameter uncertainties. The methodology developed borrows from Lyapunov based backstepping techniques. State variables are estimated complementing vision data with that available from other sensor suites. Simulation results were carried out with a simplified vehicle model. Future will address the problem of extending the techniques to sensor based control of marine vehicle models with a full set of hydrodynamic parameters.

This work has been included in a publication, submitted for acceptation to the MED Conference :

LAPIERRE L., PASCOAL A. '*Adaptive non-linear sensor-based path following control, including dynamics*' submitted for acceptation to the 10th Mediterranean Conference on Control and Automation (MED 2002), July 9-12 2002, Lisbon, Portugal.

Lisboa, January 2002
Lionel Lapierre, Ph.D.
Instituto de Sistemas e Robótica
Instituto Superior Técnico

3.2.3 ACTIVITY REPORT OF SERGEY RUMYANTZEV

This document summarizes the work that I carried out at the ISR/IST, under grant PRAXIS XXI/BPD/22118/99, during 2001. In accordance with the work plan, the research effort has been focused on control theory and its applications to ocean vehicle motion control. In what follows I summarize the key results obtained.

1. Design of PID controllers using approximations to H_∞-solutions and their applications to ship course keeping

Problem formulation. The general problem addressed is that of designing autopilots for ocean vehicles subjected to low and high frequency disturbances. The main purpose of the control law is to achieve good command tracking at low frequencies, while reducing control activity at high frequencies. A typical example for applications of this strategy of control is ship course-keeping controller design for automatic operation of vessels at sea. Satisfying these requirements under varying operating conditions requires adjusting the parameters of candidate control laws to try and meet an adequate balance between possibly conflicting objectives. It has been shown in (Miroshnikov, *et al.*, 1999) that this problem can be solved by simple shifting the Bode plot of the resulting H_∞-loop transfer function along the frequency axis. Changing parameters of weighting functions provides the above shifting. The H_∞-controllers can be adequately described by a PID structure followed by a second order low pass filter; furthermore, a PID controller as well as a filter is parameterized by a single parameter. Then, in (Miroshnikov, *et al.*, 2000) the study was addressed the problem of optimal choice of weighting functions. It has been proposed to consider indices that describe tracking accuracy and disturbance rejection for the closed-loop plant. Both the indices can be expressed via parameters of weighting functions. The approach proposed allows describing all the system performances achievable as a set on the plane. Thus, the problem of simultaneous improving tracing accuracy and disturbance rejection can be considered as one of simultaneous minimization of the two indices. The solution of this problem is a Pareto set of the indices. A simple method of finding the Pareto set was derived. The next step of research addresses the problem of designing approximating PID controllers without explicitly solving the underlying H_∞-problem.

Results obtained. By using a new method proposed, the problem of approximating controller synthesis reduces to solving a simple system of nonlinear algebraic equations. The structure of the approximating loop transfer function is known in advance. All the parameters of a PID controller and a filter can be expressed via a solution to the system of equations; and that solution can be found by resorting to standard numerical methods. Following the results obtained in (Miroshnikov, *et al.*, 2000), the region wherein the feasible starting values exist can be described in terms of Pareto-like set. The results obtained give a direct way of computing the controller parameters and simplify and unify the procedure obtained in (Miroshnikov, *et al.*, 1999). The results have been presented in (Rumyantzev *et al.*, 2001).

2. Applications of acceleration feedback methods to marine craft control

Problem formulation. Wave disturbance rejection for ocean vehicles has been addressed in the literature by resorting to advanced control theory, coupled with wave disturbance estimation. At the same time, there is a vast amount of work on disturbance rejection for mechanical structures by resorting to acceleration feedback. The key idea that is explored in many of the papers appearing in the literature is that plant disturbance acting at the input of a mechanical plant impact directly on its acceleration. Thus, it seems reasonable to use acceleration measurements to try and extract the components of the acceleration that are due to disturbances, and inject them directly at the plant input to counteract them. Such a strategy corresponds to disturbance feedback. The key problem is as to how to extract (or to observe) those components of the accelerometer signals that are due to disturbance. The problem having been solved, the command tracking and disturbance rejection problems can be treated independently. The purpose of research is to develop analytical framework for such an approach, with applications to linear and non-linear plants.

RESULTS OBTAINED

- **Algebraic disturbance feedback methods in hydrofoil craft control**

The research aims at collecting and examining various approaches centered on the notion of the disturbance feedback method based on state and state derivative feedback, where state derivative feedback is implemented as acceleration feedback. Various modifications of such an approach, with common misconceptions taken also into consideration, have been collected and examined. The hydrofoil craft longitudinal control problem (with the simplified 4th order mathematical model) was treated as a working example. It has been shown that, in spite of a large variety of different points of view, this topic has a unified analytical framework to be, in turn, used to draw a conclusion about effectiveness of AF. Such a framework has been developed for a kind of linear systems that explicitly include disturbance feedback loops due to the adopted structure of control law. The result is presented in (Rumyantzev, 2002).

- **Implementation of gain scheduled controllers with disturbance feedback loops**

The research is based on the results obtained for hydrofoil crafts and aimed at developing an analytical framework for implementation of gain-scheduled (possibly non-linear) controllers with disturbance feedback loops. The research develops the results obtained in (Kaminer *et al*., 1995) where the following problem has been solved: given a family of linear feedback controllers designed for linearizations of a non-linear plant about constant operating points, a non-linear gain scheduled controller is to be derived that preserves the input-output properties of the linear closed-loop systems locally, about each equilibrium point. The similar method is to be applied to a fairly general class of systems which linearization about constant operating point includes disturbance feedback loop. This topic is a subject of current research.

Publications

S. Rumyantzev, A. Miroshnikov, E. Popova (2001) Design of PID controllers for ship course keeping using approximations to H_∞ solutions, IFAC Workshop on Control Applications in Marine Systems (CAMS'2001), Scotland

S. Rumyantzev (2002) Algebraic disturbance feedback methods in hydrofoil craft control, The 10th Mediterranean Conference on Control and Automation (MED'2002), Lisbon, Portugal (to be submitted)

References

A. Miroshnikov, E. Popova, and S. Rumyantzev (1999) Parameterization of H_∞ suboptimal ship autopilot PID controller, Proceedings of the 14th IFAC World Congress, China, pp. 569-574.

A. Miroshnikov, E. Popova, S. Rumyantzev (2000) Pareto optimal ship course keeping controllers, Proceedings of the 5th IFAC Conference on Maneuvering and Control of Marine Crafts (MCMC'2000), Denmark, pp. 203-207.

I. Kaminer, A. Pascoal, P. Khargonekar, and E. Coleman (1995) A velocity algorithm for the implementation of gain-scheduled controllers, Automatica, Vol. 31, No. 8, pp. 1185-1191

Lisboa, January 2002
Sergey Rumyantzev, Ph.D.
Instituto de Sistemas e Robótica
Instituto Superior Técnico

3.2.4 ACTIVITY REPORT OF SANDRA CLARA GADANHO

This document presents a summary of my post-doctoral activities from the start of my program in March 2001 through to December 2001.

Research

The topic of the post-doctoral program is the study of the use of emotions and cognition in the adaptation to a rich and unstructured environment. This is also the subject of study of the project DARE shared by other members of the ISR and by the AIMS laboratory in particular.

The research work has been built upon a previous architecture (Gadanho and Hallam, 20001), which makes use of an emotion model to help a simulated mobile robot to learn a complex survival task. This architecture was based on some of the ideas proposed by (Damasio, 1994), namely that emotions have an important and positive role in decision-making.

At the ISR, the previous emotion model has been refined to capture the strong associations defended by Damasio (1994, 1999} of emotions with the basic processes of homeostatic regulation, which has already been used in some of the work developed within the DARE project.

Later a new working architecture named ALEC (Asynchronous learning by emotions and cognition) was developed. ALEC brings together two alternative decision-making systems, an emotive and a cognitive, each with separate adaptation capabilities. These two systems both have limited resources, but different strategies to deal with the richness of the real world. These different strategies complement each other --- together they outperform each one of them individually. The emotion system is based upon the previous studied architecture (Gadanho and Hallam, 20001) and the cognitive system is based on the rule system proposed within the CLARION model (Sun and Peterson 1998).

Papers

Accepted for publication

`Emotional and Cognitive Adaptation in Real Environments' Sandra Clara Gadanho. ACE2002, EMCSR'2002, Vienna, Austria, 2002 (*To Appear*).

`Learning behavior-selection in a multi-goal robot task', Sandra Clara Gadanho and Luis Custódio, NAISO ICAIS proceedings, ICSC Academic Press, 2002 (*This paper is not to be published because I was unable to attend the conference which was considered too expensive*).

`Robot Learning Driven by Emotions' Sandra Clara Gadanho and John Hallam. In Adaptive Behavior 9:1, 2001 (*To Appear*).

Published

`Emotion-triggered learning in autonomous robot control' Sandra Clara Gadanho and John Hallam. In Cañamero, D., Numaoka, C., and Petta, P., editors, Grounding emotions in adaptive systems --- A Special Issue of Cybernetics and Systems, volume 32(5). Taylor & Francis, August, 2001.

Seminars

March 16
ISR Seminar: ``Emotions in Autonomous Robot Learning''
October 17
ISR Advisory Committee Seminar: ``Learning a multi-goal real-world robot task with the help of emotions''

Students

I proposed two final projects for the 'Engenharia Electrotécnica e de Computadores and the 'Engenharia Informática e dos Computadores degrees of the IST. These projects were entitled ``*Aprendizagem por casos baseada num agente emocional*'' and ``*Evolução de agentes emocionais por algoritmos genéticos*''. The latter was taken on by the student Marco Carola and it is under my co-supervision.

Other

Active participation in the reading group about emotions of the AIMS laboratory. This provided a organized focus of interaction and discussion with the rest of the people in the laboratory.

References

Damasio, 1999
Damasio, A. (1999). *The feeling of what happens*. Harcout Brace & Company, New York.

Damasio, 1994
Damasio, A. R. (1994). *Descartes' error --- Emotion, reason and human brain*. Picador, London.

Gadanho and Hallam, 2001
Gadanho, S. C. and Hallam, J. (2001). Robot learning driven by emotions. *Adaptive Behavior*, 9(1). (*In Press*)

Sun and Peterson, 1998
Sun, R. and Peterson, T. (1998). Autonomous learning of sequential tasks: experiments and analysis. *IEEE Transactions on Neural Networks*, 9(6):1217--1234.

Lisboa, January 2002

Sandra Clara Gadanho, Ph.D.
Instituto de Sistemas e Robótica
Instituto Superior Técnico

3.3 THESES

In this section the Doctoral and Master theses concluded, or in progress, during 2001 at ISR-Lisbon are identified. In Charts 1 and 2 below the distribution by group/area of Ph.D. and M.Sc. theses is displayed.

CHART 1

Ph.D. Theses

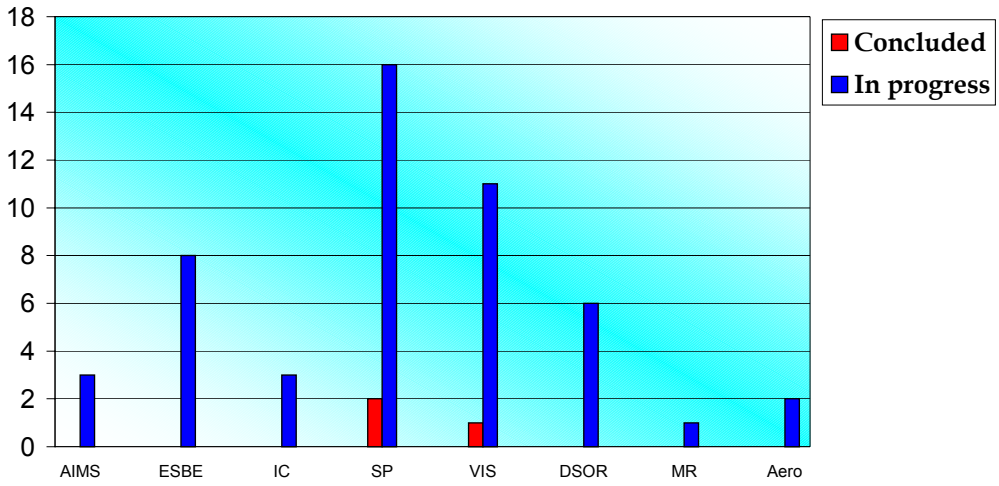
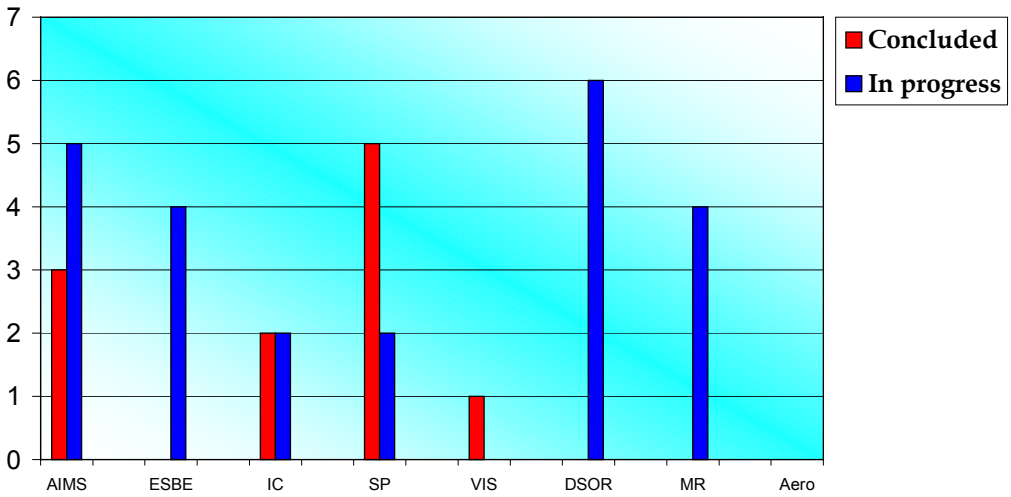


CHART 2

M.Sc. Theses



In the following a more detailed description of each thesis is given.

3.3.1 THESES CONCLUDED DURING 2001

DOCTORAL THESES (3)

- **César Silva, " 3D Motion and Dense Structure Estimation: Representations for Visual Perception and the Interpretation of Occlusions," Ph.D. Thesis, Instituto Superior Técnico, May 10th 2001, Lisboa, Portugal.**

Abstract:

This thesis addresses the problem of 3D reconstruction from a moving camera. We propose to estimate the motion of the camera and recover densely the depth of the scene, by exploring articular representations for the image information, where the occlusions play a central role.

The first part of the thesis is dedicated to the egomotion estimation problem. The approach is based on the analysis of the image motion. We introduce a family of subspaces where some constraints that use the global image motion information, are exploited to estimate the camera motion. This family of subspaces is described in a unique topological space --- the ***L***-space --- that allows the use of robust estimation tools. In order to deal with the occlusions, where the flow computation is difficult, we propose a formal model for detecting and classifying occlusions. We show how the occlusions provide additional information about the camera motion.

The second part of the thesis addresses the 3D reconstruction problem or dense matching. To approach the matching problem, we propose to explore alternative representations that may facilitate the correspondence process. Based on the order constraint, we present a new image representation called Intrinsic Images that can be used to solve the stereo correspondence within a simple and compact framework, dealing with occlusions. To overcome the need of using the order constraint, we propose a methodology for solving optimally the correspondence problem for a trinocular system, imposing solely physically meaningful constraints (uniqueness, visibility and geometric).

Several results with real images are presented for all methodologies proposed.

Keywords: Computer Vision, Egomotion Estimation, 3D Reconstruction, Occlusions, Stereo Matching, Multiple View Reconstruction.

- **Orlando Camargo Rodriguez, "Ocean Acoustic Tomography Applied to the Estimation of Internal Tides in the Continental Platform" Ph.D. Thesis, Universidade do Algarve , 2001, Algarve, Portugal.**

Abstract:

This thesis discusses the application of the methods of Ocean Acoustic Tomography to monitorize and invert the variations of internal tides in coastal environments. The material of this thesis starts with the detailed theoretical description of the propagation of internal tides, in the linear and non-linear cases. This discussion allows one to introduce the concept of Hydrostatic Normal Modes (HNMs). It is shown, in particular, that the HNMs constitute a complete orthogonal basis to represent the fields of pressure, current, temperature, sound speed and salinity. Furthermore, ray-tracing simulations are used to predict the effects of variations on wave guide geometry, and sound speed, on the temporal arrivals of the acoustic signal. The simulations allow one to develop a robust strategy of tomographic inversion, which is first tested with simulated data, and then on real acoustic data from the INTIMATE'96 experiment. Finally, it is shown that the methods of Ocean Acoustic Tomography can be efficiently applied to monitorize and invert the propagation of the internal tide, allowing one to achieve a high degree of tomographic precision.

- **Keywords**:

- **Francisco Garcia , " Detecção Passiva de Sinais Transientes " Ph.D. Thesis, Instituto Superior Técnico , June 2001, Lisboa, Portugal.**

Abstract:

This thesis reports on two problems in passive detection of transient signals:
the optimization of real-time quadratic processors, and the detection of signals in a multipath environment. It is assumed that, in both cases, the signals emitted by the source are Gaussian-distributed band pass transients; the noise has also a Gaussian distribution.
Regarding the quadratic processor optimization problem, the goal is to maximize the processor performance for a given computational complexity. It is assumed that, previous to the evaluation of the likelihood ratio, the observation process is transformed through a series of blocks (filtering, sampling, time-domain gating, linear decomposition in a smaller number of terms). These transformations reduce the computational complexity of the processor, but also limit its performance, since part of the information included in the observation process is lost. One of the parameters to be optimized is the rate at which the likelihood tests are performed in real-time which is, in general, slower than the sampling time interval. Thus, it is necessary to evaluate how the error between the time localization of an hypothetical arriving signal and its statistical model affects negatively the processor performance. A method based on the Chernoff or Bhattacharyya distances to evaluate the processor performance is proposed.
The computational complexity is measured by the total number of sums and products per time unity. Two linear decompositions are considered, the Karhunen-Loève decomposition and the discrete wavelet transform.
Detection in a multipath environment is addressed. The attenuation and delay coefficients are considered as random variables. The processing structure is developed under the assumption that the signal-to-noise ratio is low, the signal transients have short duration and the multipath environment amplifies the signal energy. The resulting processors are presented under a recursive expression, based on which a sequential scheme for replica detection is developed. This structure reduces both the computational load of the algorithm, and the mean time between the signal emission and detection. The resulting processors are robust regarding statistical errors of the multipath channel parameters.
The examples presented highlight the advantages of the proposed algorithms.

Keywords: Quadratic processor optimization, Bhattacharyya or Chernoff distances, computational complexity, sampling theorem, stochastic transient signals, passive detection, multipath environment.

MASTER THESES (11)

- **Sjoerd van der Zwaan, "Vision Based Station Keeping and Docking for Floating Robots," MSc Thesis, Instituto Superior Técnico, May 10th, 2001, Lisboa, Portugal.**

Abstract:

This thesis describes a method of vision based station keeping and docking for floating robots. Due to the motion disturbances in the environment, these tasks are important to keep the vehicle
stabilized relative to an external reference frame. A vision-based tracking system is used to measure the image deformations, as the vehicle moves with respect to a docking station. A planar surface is chosen as a reference plane which allows visual tracking of a naturally textured region, based on planar projective transformations. The tracker integrates optic flow computation within the region with a correlation based method using motion models that sample the expected image deformations over time.

These models are updated by the robot history of motion so as to accommodate predicted/future camera motions. The information provided by the tracker is then used to calculate inter-image homographies that register the current viewed image with some initial reference image. These transformations reveal the real camera motion in 3D space and allow to reconstruct the camera trajectory. This information can then be used to control the robots. Both 3D visual servoing as image based visual servoing approaches are studied. The resulting control strategies are illustrated with real experiments with a blimp and an underwater robot.

Key-words: visual tracking, optic flow, planar projective motion models, visual servoing, underwater robots, blimp, station keeping, docking.

- **Sónia Marques, "Small Satellites Attitude Determination Methods" MSc Thesis, Instituto Superior Técnico, May , 2001, Lisboa, Portugal.**

Abstract:

The determination of a satellite orientation or attitude with respect to a given coordinate system, has a major role in guidance, navigation and control, especially for autonomous systems which are less fault tolerant than ground-based systems.

This work was motivated by the need to develop a method to estimate both the attitude and the angular velocity of a low orbit small satellite, in particular the Portuguese satellite PoSAT-1. This class of satellites has a number of characteristics such as mass and volume constraints, non-linear equations of motion and noisy measurements from the attitude sensors which are not available along the whole orbit of the satellite.

Satellite attitude determination methods usually fall in one of two classes: point-to-point and recursive estimation algorithms. Point-to-point attitude determination is based on the measurements of two or more sensors in a single point in time, while recursive estimation uses information from successive time points, as well as knowledge about the spacecraft attitude dynamics model. In small satellites, only a single attitude sensor is often available, due to cost and space constraints, thus leading to the exploration of recursive estimation based solutions, such as the Kalman filter. In this work, the results of using a point-to-point Singular Value Decomposition (SVD) algorithm are compared to those obtained by an Extended Kalman Filter (EKF), when applied to a simulation of PoSAT-1. Results from the EKF, applied to the small satellite PoSAT-1 real data, is also presented.

Keywords: Attitude estimation, Quaternions, Small Satellites, Extended Kalman Filter, Point-to-point Methods.

- **Cristiano Soares , "Matched-Field Processing: Acoustic focalization with data taken in a shallow water area of the Strait of Sicily," MSc Thesis, University of Algarve, March, 2001, Faro, Portugal.**

Abstract:

Sound is used in underwater applications mainly due to the ocean's transparency to acoustic waves, whereas it is opaque to electromagnetic radiation. When an array of sensors is used to sample the acoustic field, the measured acoustic pressure appears to be highly spatially dependent both in range and depth. Matched-Field Processing (MFP) is an array
processing technique that exploits the complexity of the acoustic field to locate an acoustic source in range, depth and possibly azimuth. This is done by correlating the measured and the model predicted fields for all the source location candidates in a pre-defined grid. If the knowledge about the environmental properties is incomplete, the errors in the MFP output might be such that the source location is missed or (worst) wrongly located. It is possible to overcome this problem by estimating the environmental properties together with the source location. This is a technique close to acoustic tomography that can be viewed as a generalization of MFP and is known in the literature as environmental focalization.

In this work incoherent and coherent matched-field processors are studied and compared. The simulations illustrate that the coherent processor outperforms the incoherent processor only if the signal realizations are highly correlated at very low signal-to-noise ratio.

During the ADVENT'99 sea trial conducted by SACLANTCEN in May 1999 in the Strait of Sicily, acoustic data comprising three tracks at 2, 5 and 10 km, and on two frequency bands - 200-700 Hz and 800-1600 Hz - were acquired in a shallow water nearly range-independent area (80 m depth).

The experimental results indicate that high quality source localization can be obtained for the 5 km track and for the higher frequency band only if the environment is properly focused. In particular, the use of empirical orthonormal functions has shown to be very effective to focus the watercolumn properties, allowing for good localization results.

Keywords:

- **Nelson Martins , "A time-frequency approach to blind deconvolution in multipath underwater channels," MSc Thesis, University of Algarve, November, 2001, Faro, Portugal.**

Abstract:

Channel estimation and source deconvolution are solved in the underwater acoustics context, by time-frequency (TF) processing. The acoustic propagation environment is modelled as a multipath propagation channel.

Representation of the received signal by means of a general signal-adapted time-frequency distribution allows to visualize the resolved replicas of the emitted signal, while significantly attenuating the inherent interferences of classic TF distributions. The source instantaneous frequency estimate is the starting point for both channel and source estimation. Channel estimate is obtained via a TF formulation of the matched-filter; source deconvolution is performed by subspace-based TF inversion. This blind deconvolution approach could be incorporated on a source localization scheme or the more general problem of ocean acoustic tomography. Realistic simulated examples are presented to support this work.

Keywords:

- **Pedro Francisco Manique Silva Moita, "Concepção de um Sistema Pericial para Apoio aos Ouvintes de uma Fonoteca," MSc Thesis, March, 2001, Lisboa, Portugal.**

Abstract:

The project "MAESTRO" – the object of this thesis – aims at the development of a system to support the users of an automatic CD library. The main goal of the system is to improve the knowledge of the users, in what music is concerned. The user is supposed to interact, ina multimedia environment, with a musical *cicerone*, who suggests, according with her/his preferences, mood, and desires, a small set of musical themes, while also presents images and texts which provide contextual information to the audition. The system that includes knowledge provided by musicology researchers is an expert system, which contributes to the desideratum of implementing the concept of "active audition". The expert system contains a knowledge base, including rules and facts provided by the experts. It also includes an inference engine which, from the data provided by the users and using the represented knowledge, reaches conclusions to help the users, suggesting them sequences of musical themes for audition. In the development of the system, there were two different phases: one, devoted to characterize the knowledge and to propose a music classification model, and another directed to study the knowledge representation approach, and the prototype implementation.

Keywords:

- **Pedro Miguel Mendes Guerreiro "Modelização da detecção visual," MSc Thesis, July 20th 2001- Univ. do Algarve, Portugal.**

Abstract:

A nonlinear model of spatial visual detection has been developed. This model consists of Gabor filters, that mimic cortical simple cells, and nonlinear summation over different frequency channels. The model parameters, i.e. the gain constants of the channels, can be determined by calibrating the model to fit the contrast sensitivity function (CSF) of sinewave gratings. Then, correct predictions for other CSFs can be computed: e.g. square wave and trapezoidal gratings.

Keywords:

- **Roberto Celio Lau Lam "Alisamento adaptativo e redução de malhas triangulares," MSc Thesis , July 25th 2001- Univ. do Algarve, Portugal .**

Abstract:

Triangle meshes of 3D objects can contain hundreds of thousands vertices, especially when Marching Cubes are used. This M.Sc thesis describes an algorithm to filter adaptatively the coordinates of vertices, such that quantization noise is removed and the planarity is improved. Then, the (quasi)planar parts can be detected, the vertices eliminated, and the parts can be triangulated with much less triangles.

Keywords:

- **Ulrich Schnier "Faster isosurface extraction by marching cubes using run length encoded volume data," April 28th 2001-Collaboration Univ. of Magdeburg, Germany.**

Abstract:

The Marching Cubes method is used to create triangle meshes of volumetric data. The method analyses all neighborhoods in order to make a list of connected vertices. If a volume has been segmented, most voxel positions do not belong to a boundary, hence a lot of CPU time is waisted. This thesis describes methods to code a volume using Run Length codes, i.e. to skip empty voxels, which results in a faster processing.

Keywords:

- **Nuno Orfão " Make-to-Stock vs. Make-to-Order in the Glass Manufacturing" MSc Thesis, February 2001- Instituto Superior Técnico, Lisboa, Portugal.**

Abstract:

This thesis addresses the problem of computing the optimal parameters for production control policies in the glass manufacturing industry and provides a framework of analysis related with the structure of the production policies. We consider a multi-product, multi-stage, and capacitated discrete-time production-inventory system with random yield. Random demand occurs in each period. The optimal parameters for a given production control policy are determined in order to minimize the expected costs or reach a given service level. Three different production strategies are discussed: Make-to-Order (MTO), Make-to- Stock (MTS), and Delayed-Differentiation (DD).
We use real data (processing times, random yield factors, etc.) from a glass manufacturing company, providing simultaneously the model validation and the evaluation of the relative performance of the different strategies.
The approach used to analyze this problem will be simulation based optimization. Simulation will be used as a tool to obtain estimates of the objective function value and gradient with respect to the parameters that describe the control policy. The gradient estimation is based on Infinitesimal Perturbation Analysis.

Keywords: Capacitated Inventory Systems; Alternative Production Strategies; Random Yield; Glass Manufacturing; Infinitesimal Perturbation Analysis.

- **José António Alves Moreira " Distributed Scheduling with Active Idleness: Key to the stabilization of multiclass queuing networks " MSc Thesis, June 2001- Instituto Superior Técnico, Lisboa, Portugal.**

Abstract:

This thesis presents a supervisory mechanism that is able to stabilize any non-acyclic, stochastic, multiclass queuing network with a distributed scheduling policy. The Traffic Intensity Condition has to hold as well as some mild assumptions on the service and arrival distributions.
This mechanism is based on the Active Idleness concept. By Active Idleness it is meant the scheduler's ability to force inactivity on the server, even in the presence of work. Although this ability appears as leading to a waste of the available resources, the important factor is to look at the queuing network as a whole. What might appear as a loss of resources when looking to an individual server, could in fact be highly beneficial for the performance of the entire queuing network.
The thesis presents one possible implementation of the concept, termed Time Window Controller, and illustrates its ability to, not only stabilize, but also improve the performance of some stable non-acyclic, stochastic, multiclass queuing networks, independently of the performance measure under consideration.

Keywords: Queuing Networks, Distributed Scheduling, Stability, Idling Policies, Active Idleness.

- **Carlos Marques "Multi-Sensor Navigation for Soccer Robots," MSc Thesis, March 2001- Instituto Superior Técnico, Lisboa, Portugal**

Abstract:

This thesis presents a method for robot navigation in structured indoors environments, based on the information of multiple sensors. A catadioptric omni-directional vision sensor is used for self localization, from the extraction of natural geometric landmarks of the environment. It is assumed that the robot moves on at surfaces and straight lines can be identified in the surrounding environment by the catadioptric system. The guidance control algorithm, which takes the robot to a desired posture, is based on odometry and its periodic reset by the self-localization system, and uses sonar data to avoid and move around obstacles. Results from the application to a real soccer robot moving on a RoboCup soccer field are presented.

Keywords: Natural Landmark-Based Navigation, Self-Localization, Omni-Directional Catadioptric Vision System, Guidance Algorithms, soccer Robotics

3.3.2 THESES IN PROGRESS DURING 2001

In this subsection the Doctoral and Master theses in progress during 2000, at ISR/IST (ECE) and ISR/Algarve (ECE), are identified.

DOCTORAL THESES (50)

Research Area: Artificial Intelligence
Title: Spatial Reasoning – The N-Dimensional Projective Approach
Doctoral Student: Jorge Miguel Pais
Advisor: Carlos Alberto Pinto-Ferreira
Initiated: 1997
Expected conclusion: 2002
Current Status: On-going
Documents produced in 2001:

Research area: Artificial Intelligence
Title: Emotion-based Agents
Doctoral Student: Rodrigo Ventura
Advisor: Carlos Alberto Pinto-Ferreira
Initiated: 2000
Expected conclusion: 2004
Current status: On-going
Documents produced in 2001:

Research Area: Computer Vision
Title: 3D Reconstruction of Structured Scenes from one or more views
Doctoral Student: Etienne Grossmann
Advisor: José Santos-Victor
Initiated: 1997
Expected conclusion: 2002
Current Status: On-going
Grant: FCT
Documents produced in 2001: [71] [75]

Research Area: Computer Vision
Title: Binocular Visual Servoing
Doctoral Student: Alexandre Bernardino
Advisor: José Santos-Victor
Initiated: 1997
Expected conclusion: 2002
Current Status: On-going
Documents produced in 2001: [73] [81]

Research Area: Computer Vision
Title: Visual Navigation based on Panoramic Image sensors
Doctoral Student: José António Gaspar
Advisor: José Santos-Victor
Initiated: 1997
Expected conclusion: 2002
Current Status: On-going
Documents produced in 2001: [71] [72]

Research Area: Computer Vision
Title: Global matching: optimal solution to correspondence problems
Doctoral Student: João Maciel
Advisor: João Paulo Costeira
Initiated: 1997
Expected conclusion: 2002
Current Status: Finished
Grant: PRAXIS XXI
Documents produced in 2001:

Research Area: Computer Vision
Title: Video Mosaics for Navigation
Doctoral Student: Nuno Gracias
Advisor: José Santos-Victor
Initiated: 1998
Expected conclusion: 2002
Current Status: On-going
Grant: PRAXIS XXI
Documents produced in 2001: [30] [77] [79]

Research Area: Computer Vision
Title: Not yet available
Doctoral Student: Raquel Vassalo
Advisor: Hans Schneebeli
Co-Advisor: José Santos-Victor
Initiated: 2000
Expected conclusion: 2004
Current Status: On-going
Grant: CAPES (Brasil)
Documents produced in 2001:

Research Area: Computer Vision
Title: An Holistic approach to Topological Navigation using Omnidirectional Vision
Doctoral Student: Niall Winters
Advisor: José Santos-Victor
Initiated: 1998
Expected conclusion: 2002
Current Status: Defence held with success January 2002.
Grant: IST/ISR
Documents produced in 2001: [70] [72] [76] [78]

Research Area: Computer Vision Robotics
Title: Not yet available
Doctoral Student: Manuel Lopes
Advisor: José Santos Victor
Initiated: 2000
Expected conclusion: 2004
Current Status: On-going
Grant: PRAXIS XX
Documents produced in 2001:

Research Area: Computer Vision
Title: Not yet available
Doctoral Student: Claudia Deccò
Advisor: José Santos-Victor
Initiated: 2000
Expected conclusion: 2004
Current Status: On-going
Grant:
Documents produced in 2001:

Research Area: Computer Vision
Title: Not yet available
Doctoral Student: Lenildo Silva
Advisor: José Santos-Victor
Initiated: 1999
Expected conclusion: 2003
Current Status:
Grant:
Documents produced in 2001:

Research Area: Computer Vision Robotics
Title: Not yet available
Doctoral Student: Freek Stulp
Advisor: José Santos Victor
Initiated: 2000
Expected conclusion: 2004
Current Status: On-going
Grant:
Documents produced in 2001:

Research Area: Biomedical Engineering
Title: Sleep EEG Microstructure Analysis
Doctoral Student: Rogério Largo
Advisor: Agostinho Rosa
Initiated: 1996
Expected conclusion: 2002
Current Status: on-going
Documents produced in 2001:

Research Area: Evolutionary Systems - Schedulling
Title: Simulated Annealing in Resource Management
Doctoral Student: Fernando Melício
Advisor: Agostinho Cláudio da Rosa
Initiated: 1998
Expected Conclusion: 2002
Current Status: started
Documents produced in 2001:

Research Area: Evolutionary Systems – Optimization and Image Enhancement
Title:
Doctoral Student: Cristian Munteanu
Advisor: Agostinho Cláudio da Rosa
Initiated: Jan 2001
Expected Conclusion: 2003
Current Status: started
Grant: Sapiens 2001
Documents produced in 2001:

Research Area: Artificial Life – Evolutionary Systems
Title:
Doctoral Student: Gong Hongfei
Advisor: Agostinho Cláudio da Rosa
Initiated: October 1999
Expected Conclusion: 2003
Current Status: on-going
Grant: ISR-Plurianual
Documents produced in 2001:

Research Area: Artificial Life – Social Systems
Title: Design and Development of Highly Flexible Organizations
Doctoral Student: Osvaldo Brasão
Advisor: Agostinho Cláudio da Rosa
Initiated: July 1999
Expected Conclusion: 2003
Current Status: on-going
Grant: Praxis XXI
Documents produced in 2001:

Research Area: NeuroSciences
Title:
Doctoral Student: Ernesto Soares
Advisor: Agostinho Cláudio da Rosa
Initiated: July 1999
Expected Conclusion: 2003
Current Status: on-going
Grant: Calouste Gulbenkian Foundation
Documents produced in 2001:

Research Area: Biomedical Engineering - Neuroscience
Title: Detection of Neurocognitions
Doctoral Student: Jose Luis Malaquias
Advisor: Agostinho Cláudio da Rosa
Initiated: September 2000
Expected Conclusion: 2004
Current Status: on-going
Grant:
Documents produced in 2001:

Research Areas: Biomedical Engineering - vision
Title: Objects representation and identification
Doctoral Student: Tito Silva
Advisor: Agostinho Cláudio da Rosa
Initiated: 1997
Expected Conclusion: 2001
Current Status: Delivered
Grant: PRAXIS XXI
Documents produced in 2001:

Research Area: Hybrid Systems, Multi-Agent Formations
Title: Hierarchies and Compositional Abstractions of Hybrid Systems
Doctoral Student: Paulo Tabuada
Advisor: Pedro M. U. A. Lima
Initiated: 1998
Expected conclusion: January 2002
Current Status: On-going
Grant:
Documents produced in 2001: [52] [53] [54] [55] [57] [58] [59] [61] [150]

Research Area: Discrete Event Systems, Robotic Task Supervision/Coordination
Title:
Doctoral Student: Dejan Milutinovic
Advisor: Pedro M. U. A. Lima
Initiated: September 2000
Expected conclusion: 2004
Current Status: On-going
Documents produced in 2001: [60]

Research Area: Satellite Formations State Determination and Control
Title:
Doctoral Student: Sónia Marques
Advisor: Pedro M. U. A. Lima
Initiated: September 2001
Expected conclusion: 2005
Current Status: On-going
Documents produced in 2001:

Research Area: Outdoords Navigation of Mobile Robots
Title: Not yet available
Doctoral Student: Alberto Vale
Advisor: Maria Isabel Ribeiro
Initiated: December 1999
Expected conclusion: 2004
Current Status: on-going
Grant: Ph.D grant from FCT
Documents produced in 2001:

Research Area: Telecommunications
Title: Not yet available
Doctoral Student: Emanuel Ribeiro
Advisor: Victor Barroso
Initiated: 2001
Expected conclusion: 2004
Current status: on-going
Grant:
Documents produced in 2001:

Research Area: Image Compression
Title: Not yet available
Doctoral Student: Jorge Barbosa
Advisor: Victor Barroso
Initiated: 1996
Expected conclusion: 2000/2001
Current Status: on-going
Grant: PRODEP
Documents produced in 2001:

Research Area: Blind Equalization
Title: Not yet available
Doctoral Student: João P. Gomes
Advisor: Victor Barroso
Initiated: 1997
Expected conclusion: 2000/2001
Current Status: on-going
Grant:
Documents produced in 2001:

Research Area: Time-Frequency Signal Analysis
Title: Not yet available
Doctoral Student: Paulo Mónica
Advisor: Victor Barroso
Initiated: 1997
Expected conclusion: 2000/2001
Current Status: on-going
Grant:
Documents produced in 2001:

Research Area: Array Processing
Title: Not yet available
Doctoral Student: João Xavier
Advisor: Victor Barroso
Initiated: 1997
Expected conclusion: 2000/2001
Current Status: on-going
Grant:
Documents produced in 2001:

Research Area:
Title: Not yet available
Doctoral Student: Dusan Ramljak
Advisor: Victor Barroso
Initiated: 2001
Expected conclusion: 2004
Current Status: on-going
Grant:
Documents produced in 2001:

Research area: Video Segmentation
Title: Not yet available
Doctoral Student: Pedro M. Jorge
Advisor: Jorge S. Marques
Initiated: 1998
Expected conclusion: 2002
Grant:
Current status: on going
Documents produced in 2001:

Research area: 3D Ultrasound
Title: Not yet available
Doctoral Student: João Sanches
Advisor: Jorge S. Marques
Initiated: 1998
Expected conclusion: 2002
Grant:
Current status: on going
Documents produced in 2001:

Research area: Tracking of Moving Objects with Multiple Models
Title: Not yet available
Doctoral Student: Jacinto Nascimento
Advisor: Jorge S. Marques
Initiated: 1998
Expected conclusion: 2002
Grant: PRAXIS XXI
Current status: on going
Documents produced in 2001:

Research area: Underwater Acoustic Communications
Title: to de decided
Doctoral Student: António João Silva
Advisor: Sérgio Jesus
Initiated: 1998
Expected conclusion: 2001
Current status: on going
Grant:
Documents produced in 2001:

Research area: image processing, visual psychophysics
Title: A new spatial brightness model
Doctoral Student: João Rodrigues
Advisor: Hans du Buf
Initiated: 1998
Expected conclusion: 2002
Current status: on going
Grant: PRODEP
Documents produced in 2001:

Research area: Processamento de Imagem em 3D
Title: 2D and 3D data Processing and visualization
Doctoral Student: Robert Loke
Advisor: Hans du Buf
Initiated: 1998
Expected conclusion: 2003
Current status: on going
Grant: European project ADIAC ans ISACS
Documents produced in 2001:

Research area: Processamento de Imagem
Title: Models of cortical neurons in pattern recognition
Doctoral Student: Luis Santos
Advisor: Hans du Buf
Initiated: 2000
Expected conclusion: 2004
Current status: on going
Grant: FCT
Documents produced in 2001:

Research area: Computação Gráfica
Title: 3D object Reconstruction and Triangulation
Doctoral Student: Roberto Lam
Advisor: Hans du Buf
Initiated: 2001
Expected conclusion: 2005
Current status:
Documents produced in 2001:

Research area: Processamento de Imagem
Title: Detection and brightness modes
Doctoral Student: Pedro Guerreiro
Advisor: Hans du Buf
Initiated: 2001
Expected conclusion: 2005
Current status: on going
Documents produced in 2001:

Research area: Underwater acoustic signal processing
Title: Data Fusion Applied to Ocean Acoustic Tomography
Doctoral Student: Paulo Felisberto
Advisor: Sérgio de Jesus
Initiated: June 2001
Expected conclusion: 2004
Current status: on going
Grant: PRODEP
Documents produced in 2001:

Research Area: Filtering Theory.
Title: Periodic and Nonlinear Estimators with Applications to the Navigation of Ocean Vehicles.
Doctoral Student: Paulo Oliveira
Advisor: António Pascoal
Initiated: 1994.
Expected Conclusion: 2002
Current Status: submitted
Grant: Teaching Staff of IST
Documents produced in 2001: [132] [162]

Research Area: Nonlinear Control Theory
Title: Nonlinear Path Following Control Systems for Ocean Vehicles.
Doctoral Student: Pedro Encarnação
Advisor: António Pascoal
Initiated: October 1997
Expected Conclusion: 2002
Current Status: submitted
Grant: PRAXIS XXI
Documents produced in 2001: [96] [98] [99] [102] [161]

Research Area: Nonlinear Control Theory
Title: Nonlinear Motion Control of Nonholonomic and Underactuated Systems.
Doctoral Student: António Aguiar
Advisor: António Pascoal
Initiated: October 1997.
Expected Conclusion: 2002
Current Status: submitted
Grant: PRAXIS XXI
Documents produced in 2001: [98] [101] [160] [163] [164] [169] [170] [171]

Research Area: Marine Robotics
Title: Identification and Control of Surface Craft
Doctoral Student: Fei Chun Ma
Advisor: António Pascoal
Initiated: 2000
Expected Conclusion: 2004
Current Status: research in progress
Documents produced in 2001:

Research Area: Navigation
Title: Terrain Based Navigation of Autonomous Underwater Vehicles (AUVs)
Doctoral Student: Francisco Curado Teixeira
Advisor: António Pascoal
Initiated: 2000
Expected Conclusion: 2004
Current Status: research in progress
Documents produced in 2001:

Research Area: Control Theory
Title: Robust Control with Applications to Autonomous Vehicles
Doctoral Student: Sajjad Fekri Asl
Advisor: António Pascoal / Michael Athans
Initiated: 2001
Expected Conclusion: 2005
Current Status: research in progress
Documents produced in 2001:

Research Area: Aeroacoustics
Title: Acoustics of Boundary Layers
Doctoral Student: Pedro G.T.A. Serrão
Advisor: L.M.B.C. Campos
Initiated: 1997
Conclusion: 2002
Current Status: In progress
Documents Produced in 2001:

Research Area: Aeroacoustics
Title: Acoustics of Shear Flows
Doctoral Student: João M. G. Oliveira
Advisor: L.M.B.C. Campos
Initiated: 1997
Conclusion: 2002
Current Status: In progress
Documents Produced in 2001:

Research Area: Operations Management – Queuing networks
Title: To be defined
Doctoral Student: Nuno Manuel Rosa dos Santos Órfão
Advisor: Carlos Bispo
Initiated: 2001
Expected conclusion: 2005
Current status: course work/readings
Grant:
Documents produced in 2001:

MASTER THESES (23)

Research Area: Artificial Intelligence
Title: Emotion-based Agents in Social Contexts
Master Student: Márcia Maçãs
Advisor: Luis Custódio
Initiated: 1999
Expected conclusion: 2002
Current status: Finished
Grant:
Documents produced in 2001:

Research Area: Artificial Intelligence
Title: Learning for Emotion-based Agents
Master Student: Pedro Vale
Advisor: Luis Custódio
Initiated: 1999
Expected conclusion: 2002
Current status: Finished
Documents produced in 2001:

Research Area: Artificial Intelligence
Title: Manufacturing Systems Control using Societies of Agents
Master Student: Ivone Fernandes
Advisor: Luis Custódio
Initiated: 1999
Expected conclusion: 2002
Current status: On-going
Grant:
Documents produced in 2001:

Research Area: Artificial Intelligence
Title: Supply-Chains : an Multi-agent System Approach
Master Student: Rui Carvalho
Advisor: Luis Custódio
Initiated: 2001
Expected conclusion: 2003
Current status: On-going
Documents produced in 2001:

Research Area: Artificial Intelligence
Title: Emotion-based Agent Architectures
Master Student: Bruno Damas
Advisor: Luis Custódio
Initiated: 2001
Expected conclusion: 2003
Current status: On-going
Documents produced in 2001:

Research Area: Evolutionary Systems
Title: Algoritmos Evolutivos: Paradigma Infecção Genética
Master Student: Rui Tavares
Advisor: Agostinho Rosa
Initiated: 1997
Expected Conclusion: Submitted in 2000
Current Status: Delivered
Documents produced in 2001:

Research Area: Biomedical Engineering
Title: Not yet available
Master Student: João Paulo Caldeira
Advisor: Agostinho Rosa
Initiated: 1997
Expected Conclusion: 2002
Current Status: On-going
Grant:
Documents produced in 2001:

Research Area: Evolutionary Systems
Title: Population based Genetic Algorithms
Master Student: Carlos Fernandes
Advisor: Agostinho Rosa
Initiated: 2000
Expected Conclusion: Submitted in 2002
Current Status: Delivered
Grant:
Documents produced in 2001:

Research Area: Evolutionary Systems - BioChemistry
Title:
Master Student: Nelson Pereira
Advisor: Agostinho Rosa
Initiated: 2000
Expected Conclusion: 2002
Current Status: on-going
Grant:
Documents produced in 2001:

Research Area: Process Operation and Control
Title: Operation and Control of a Glass Melting Furnace
Master Student: João Pina
Advisor: Pedro M. U. A. Lima
Initiated: 1997
Expected conclusion: December 2001
Current Status: Waiting for thesis defense
Documents produced in 2001:

Research Area: Architectures for Autonomous Intelligent Machines
Title:
Master Student: Paulo Alvito
Advisor: Pedro M. U. A. Lima
Initiated: 1995
Expected conclusion: 2002
Current Status: On-going
Documents produced in 2001:

Research Area: Inteligent Control
Title:
Master Student: Hugo Furtado
Advisor: Pedro M. U. A. Lima
Initiated: 2001
Expected conclusion: 2003
Current Status: On-going
Documents produced in 2001:

Research Area: Navigation of Mobile Robots
Title: Uma Arquitectura de Navegação para Robots Móveis
Master Student: José Paulo C. C. Castro
Advisor: Maria Isabel Ribeiro
Initiated: 1996
Expected conclusion: 2002
Current Status: On-going
Grant: no grant in 2000
Documents produced in 2001:

Research Area: Localisation of Mobile Robots
Title: Localisation of a Mobile Robot using Laser Scanner and reconstructed 3D models
Master Student: João da Silva Gomes-Mota
Advisor: Maria Isabel Ribeiro
Initiated: 1996
Expected conclusion: 2002
Current Status: submitted in December 2001
Grant: no grant in 2001
Documents produced in 2001: [121]

Research Area: High-level architecture description for Mobile Robotics
Title: Not yet available
Master Student: Sérgio Guerreiro
Advisor: João Sequeira
Initiated: 2000
Expected conclusion: 2002
Current Status: On-going
Grant: None
Documents produced in 2001: [144]

Research Area: Industrial Robotics
Title: Not yet available
Master Student: Inácio Rocha
Advisor: João Sequeira
Initiated: 2001
Expected conclusion: 2002
Current Status: On-going
Documents produced in 2001:

Research Area: Signal Processing
Title: Not yet available
Master Student: Rui Cruz
Advisor: Victor Barroso
Initiated: 2000
Expected conclusion: 2003
Current status:
Grant:
Documents produced in 2001:

Research Area: Real Time Systems
Title: Distributed Architectures for Real-Time Control
Master Student: João Alves
Advisor: Carlos Silvestre
Initiated: October 2000
Conclusion: 2002
Current Status: research in progress
Grant:
Documents produced in 2001:

Research Area: Mission Control Systems
Title: Development of a Mission Control System for Autonomous Vehicles
Master Student: Carlos Ferreira
Advisor: Carlos Silvestre
Initiated: October 2000
Conclusion: 2002
Current Status: research in progress
Grant:
Documents produced in 2001:

Research Area: Robotics
Title: Modeling and Control of an Autonomous Ocean Vehicle.
Master Student: Miguel Prado
Advisor: António Pascoal
Initiated: September 1995.
Conclusion: 2002
Current Status: writing in progress
Grant:
Documents produced in 2001:

Research Area: Marine Robotics.
Title: Visual Detection and Maneuvering of Surface Crafts
Master Student: Luella Wong
Advisor: Paulo Costeira / António Pascoal
Initiated: October 1998
Conclusion: 2002
Current Status: writing in progress
Documents produced in 2001:

Research Area: Robotics
Title: Modeling and Control of an Autonomous Robotic Helicopter
Master Student: Rita Cunha
Advisor: Carlos Silvestre
Initiated: January 2000
Conclusion: 2002
Current Status: submitted
Grant: PRAXIS XXI
Documents produced in 2001: [166]

Research Area: Tracking Systems
Title: Prediction and Tracking of Moving Targets in 2D
Master Student: Pedro Alves
Advisor: Carlos Silvestre
Initiated: October 2000
Conclusion: 2002
Current Status: submitted
Grant: PRAXIS XXI
Documents produced in 2001:

3.4 ADVANCED TRAINING

3.4.1 COURSES

João Sentieiro – Nonlinear Programming , Ph. D. Course, IST

Michael Athans – Dynamic Stochastic Estimation Prediction and Smoothing, Ph. D. Course , IST

José Santos Victor – Computer Vision, M. Sc. Course, IST

Paulo Tabuada - Courses on Geometric Non-Linear Control

Pedro Lima - Discrete Event Systems to ISR/IST Systems and Control Theory group.

Pedro Lima - Master's course on "Mobile Robotics"

Victor Barroso - Course on "Stochastic Processes" (internal offer for the ISR´s and IT´s students)

Francisco Garcia - A postgraduate course on Fourier transform and wavelets

Luis Custódio – Artificial Intelligence, M.Sc. Course, IST.

Luis Custódio – Modelling and Control of Automated Manufacturing Systems, MSc. Course, IST

António Pascoal - Course on Nonlinear Control (internal offer for ISR students and post-docs).

3.4.2 SEMINARS

STRUCTURE AND PERFORMANCE OF THE ASIMOV ACOUSTIC COMMUNICATION SYSTEM
João Pedro Gomes - Ph.D. Student, ISR, IST
17:00 h, Friday, January 5, 2001

ALGEBRAIC ASPECTS OF RECONSTRUCTION OF STRUCTURED SCENES FROM ONE OR MORE VIEWS
Etienne Grossman - Ph.D. Student, ISR, IST
17:00 h, Friday, January 12, 2001

APPLICATION OF BEAM - FORMING ADAPTIVE ALGORITHMS FOR THE UNIVERSAL MOBILE COMMUNICATIONS
João Miguel Gil - Ph.D. Student, IT, IST
17:00 h, Friday, January 19, 2001

COMBINED PLANT CONTROLLER OPTIMIZATION FOR AUTONOMOUS UNDERWATER VEHICLES
Carlos Silvestre - Professor, ISR, IST
17:00 h, Friday, January 26, 2001

SCENE LEVEL RATE CONTROL ALGORITHM FOR MPEG-4 VIDEO CODING
Paulo Nunes - Ph.D. Student, IT, IST
17:00 h, Friday, February 2, 2001

FEASIBLE FORMATIONS OF MULTI-AGENT SYSTEMS
Paulo Tabuada - Ph.D. Student, ISR, IST
17:00 h, Friday, February 9, 2001

ATTENTION MECHANISMS AND VISUAL TRACKING
Alexandre Bernardino - Ph.D. Student, ISR, IST
17:00, Friday, February 16, 2001

A NEW AI APPROACH TO EMOTIONS SYNTHESIS
Carlos Herrera Perez, Ph.D. Student, Caledonian University of Glasgow
17:00 h, Friday, February 23rd 2001

ALGEBRA AND ALGORITHMS FOR QoS PATH COMPUTATION AND HOP-BY-HOP ROUTING IN THE INTERNET
João Luís Sobrinho - Professor, IT, IST
17:00, Friday, March 2, 2001

ALIGNMENT-BY-RECONSTRUCTION FOR 3D ULTRASOUND IMAGING
João Sanches - Ph.D. Student, ISR, IST
17:00, Friday, March 9, 2001

EMOTIONS IN AUTONOMOUS ROBOT LEARNING
Sandra Gadanho - Post-Doc, ISR, IST
17:00, Friday, March 16, 2001

A MARKOV POINT PROCESS FOR ROAD EXTRACTION IN REMOTELY SENSED IMAGES
Josiane Zerubia - Ph.D., INRIA Sophia-Antipolis, France
15:00, Friday, March 28, 2001

ON COOPERATION AND AUTONOMY IN MULTIAGENT AND MULTIROBOT SYSTEMS
Gerhard Kraetzschmar - Professor, University of Ulm, Germany
17:00, Friday, March 30, 2001

THE COOL SCIENCE INSTITUTE:PROMOTING EDUCATIONAL ROBOTICS TO RAISE THE INTEREST OF CHILDREN FOR SCIENCE AND TECHNOLOGY.
Gerhard Kraetzschmar - Professor, University of Ulm, Germany
18:00, Friday, March 30, 2001

OBSERVER-BASED CONTROL OF PIECEWISE-AFFINE SYSTEMS
Luís Rodrigues - Ph.D. Student, Stanford University, USA
17:00, Friday, April 6, 2001

SMALL SATELLITES ATTITUDE DETERMINATION METHODS
Sónia Marques - M.Sc.Student, ISR, IST
17:00, Friday, April 20, 2001

SCALING LAWS: A WAVELET CHARACTERIZATION
Paulo Gonçalves - Ph.D., INRIA Rhône-Alpes, France
15:00, Wednesday, April 18, 2001

DESIGN OF AN ACTIVE SONAR FOR MEASURING BUBBLE CLOUDS UNDER BREAKING WAVES
Roberta Quant - Ph.D. Student, ISR, IST
17:00, Friday, April 27, 2001

THE EXTENSION OF THE EULER THEOREM TO n-DIMENSIONAL SPACES
Daniele Mortari - Ph.D., Universita degli Studi La Sapienza di Roma, Centro di Ricerche Progetto San Marco
17:00, Friday, May 4, 2001

COMPOSITIONAL ABSTRACTIONS OF HYBRID CONTROL SYSTEMS
Paulo Tabuada - Ph.D. Student, ISR, IST
17:00, Friday, May 11, 2001

SPATIAL MODULATION FOR UNDERWATER ACOUSTIC COMMUNICATIONS USING PHASE CONJUGATION
João Pedro Gomes - Ph.D. Student, ISR, IST
17:00 h, Friday, May 18,2001

COMBINED GABOR FILTER SEGMENTATION AND 3D VECTOR QUANTIZATION TO VLBR VIDEO COMPRESSION OF UNDERWATER VIDEO SEQUENCES
Jorge Barbosa - Ph.D. Student, ISR, IST
17:00 h, Friday, May 25, 2001

PHYSICAL CONSTRAINTS ON THE TIME-FREQUENCY PLANE
Paulo Mónica de Oliveira - Ph.D. Student, ISR, IST
17:00 h, Friday, June 1, 2001

ROBUST SHAPE TRACKING IN THE PRESENCE OF CLUTTERED BACKGROUND
Jacinto Nascimento - Ph.D. Student, ISR, IST
17:00 h, Friday, June 8, 2001

MOMENT PROBLEMS AND THEIR APPLICATIONS
Professor Dimitris Bertsimas, Sloan School of Management, MIT
Quarta-feira, June 20, VA1, 15:00

NON-LINEAR TRACKER FOR JOINT ASC/AUV OCEANIC MISSIONS
Paulo Oliveira - Ph.D. Student, ISR, IST
17:00 h, Friday, June 22, 2001

SERVICE ROBOTS
Henrik I Christensen, Centre for Autonomous Systems, Royal Institute of Technology, Sweden.
17h 30m,Tuesday, October 2, 2001

NETWORKED EMBEDDED CONTROL SYSTEMS: ISSUES AND CHALLENGES
Panos J. Antsaklis, Department of Electrical Engineering, University of Notre Dame, USA.
17h 30m, Wednesday, October 17, 2001

HIDDEN MARKOV MODELS - THEORY AND APPLICATION TO 2D SHAPE RECOGNITION
Manuele Bicego, University of Verona, Italy
17h00m, Friday, October 19, 2001

ADAPTIVE SPARSE REGRESSION
Mário A. T. Figueiredo, IT/IST
17h30m, Friday, October 26, 2001

THE BETAI PARAMETERIZED TEMPERATURE CONTROLLER
Dejan Milutinovic, Ph.D. Student, ISR-IST
17:00h, Friday, November 9, 2001

MOVING TARGETS IMAGING AND TRAJECTORY ESTIMATION USING ALIASED SYNTHETIC APERTURE RADAR DATA
Paulo A. C. Marques, IT-IST / ISEL
17:00h , Friday, November 16, 2001

ANALYSIS OF MUSICAL EXPRESSIVITY: AN EXPERIMENT ON PIANO IMPROVISATION
Filippo B. Baraldi, Center for Computational Sonology, University of Padua, Italy
17:00h, Friday, November 30, 2001

AUTOMATIC TRACKING OF MULTIPLE PEDESTRIANS WITH GROUP FORMATION AND OCCLUSIONS
Pedro Mendes Jorge, Secção de Comunicações e Processamento de Sinais, ISEL
17:00h , Friday, December 7, 2001

3.4.3 READING GROUPS

Reading group on Discrete Event Systems, (AIMS, IC and MR)

Reading group on Computer Vision (VISLAB)

Reading group on Artificial Emotions (AIMS, IC)

Reading group on Multi-Agent Systems (AIMS, IC)

Reading group on Non-linear Control of Autonomous Vehicles (DSOR)

3.4.4 VISITS ABROAD

João Sentieiro participated as national delegate to the Scientific Program Committee of the European Space Agency in several meetings in Paris (F) and Nordwijck (N).

Pedro Lima participated in *RoboCup 2001*, in Seattle, 2-10 August, as part of the *IsocRob Team*, competing in the middle-size league, as well as in the *RoboCup Workshop 2001*.

3.4.5 SUPERVISION OF STUDENTS ENROLLED IN FOREIGN UNIVERSITIES

Carlos Herrera Perez. PhD Student from Caledonian University of Glasgow, May 2001 to September 2001

Fillipo Bonini, Undergraduated Student from Padua University, Italy, 2001

Raquel Vassalo, Ph.D.Student from Univ. Federal do Espírito Santo, Brazil, 2001

Freek Stulp, M.sc. Student from Univ. of Groeningem , Netherlands, 2001

Marco Zucchelli, Ph.D. Student from Royal Institute of Technology, Sweden, 2001

Niall Winters, Ph.D. Student from Trinity College, Dublin, Ireland, 2001

Javier Minguez, Ph.D. Student from University of Saragoza, Spain, 2001

Diego Ortin Trasobares, Ph.D. Student from University of Saragoza, Spain, 2001

3.5 CONGRESS, MEETINGS AND PRESENTATIONS

This section includes invited talks, conferences attended and conferences where papers were presented, during 2001, by ISR-Lisbon researchers.

3.5.1 INVITED TALKS

José Santos-Victor - "Using vision for underwater robotics: video mosaics and station keeping," 1st International Workshop on Underwater robotics for Sea Exploitation and Environmental Monitoring, Rio de Janeiro, Brasil, October 2001.

José Santos-Victor - "Vision-based Navigation, Environmental Representations and Imaging Geometries," *10th International Symposium of Robotics Research – ISRR*, Lorne, Victoria, Australia, 9-12 Novembro 2001.

M. Isabel Ribeiro - invited talk "The cycle prediction-matching-filtering in the localization of mobile robots". University of Aveiro, January 2001.

Carlos Bispo - invited talk, "Research overview," Spring Course on Stochastic Optimization, Universidade de Coimbra, Coimbra, Portugal, May 2001.

Agostinho Rosa - "Applications of random heuristic search algorithms". Faculdade de Motricidade Humana, 9 de Novembro de 2001.

Agostinho Rosa - "Introduction to Evolutionary Computation a class of heuristic search algorithms". Fakultat fur Elektrotechnik und Informationstechnik – Institut fur Elektro- und Biomedizinische Technik", Technical University of Graz, Maio de 2001.

Sergio Jesus - Jesus S.M. and Soares C., "Broadband MFP: coherent vs. incoherent", MTS/IEEE Oceans 2001, Hawai, USA, November.

António M. Pascoal – "Marine Robots: Advanced Tools for Marine Habitat Mapping," Workshop on Deep Seabed Survey Technologies, Bergen, Norway, February 2001.

António M. Pascoal – "Navigation, Guidance, and Control of AUVs", National Institute of Oceanography, Dona Paula, Goa, India, February 2001.

António M. Pascoal - "Marine Robots: Instruments for Ocean Exploration", CULTURGEST Cycle of Conferences, Lisbon, 18 April, 2001.CLUTLUL 2001

António M. Pascoal – "Marine Robots", Second Series of Meetings organized by the Commission of the "Licenciatura" in Electrical and Computers Engineering, Instituto Superior Técnico, 21 April, 2001.

António M. Pascoal – "The DELFIM autonomous craft: system design and development and testing at sea: the INFANTE and ASIMOV projects ", INTIFANTE Workshop, Faro, Algarve, May 10, 2001.

António M. Pascoal – "Robotic Technologies for Ocean Exploration", Congress / Science and Technology of Spain and Portugal at the Turn of the Century, Lisbon, Portugal, Nov. 2001.

3.5.2 PARTICIPATIONS

During 2001 ISR-Lisbon researchers participated in the following conferences, workshops and meetings:

IEEE International Workshop on Signal Processing Advances for Wireless Communications, SPAWC'01, Taoyuan, Taiwan, R.O.C., March 2001

IEEE International Conference on Acoustics, Speech and Signal Processing, ICASSP 2001, Salt Lake City, USA, April 2001

IEEE International Symposium on Information Theory, Washington D.C., USA, June 2001

IEEE Conference on Oceanic Engineering, OCEANS 2001, Honolulu, Hawaii, USA, November 2001.

IEEE Int. Conf. Image Processing, ICIP'01, Greece

IEEE 2001 Conference on Decision and Control, Orlando, FL, USA

American Control Conference '01, Arlington, VA, USA

RoboCup Workshop 2001, Seattle, USA

ECC'01, Porto, Portugal

NOLCOS'2001, Saint- Petersburg, RUSSIA

Hybrid Systems: Computation and Control, Fourth International Workshop, Rome, Italy

1st Workshop on Robotics Education and Training, RET2001, Weingarten, Alemanha, Julho de 2001.

Summer School on Robotics Navigation, EPFL, Lausanne, September 2001.

Spring School on Stochastic Optimization, Departamento de Matemática, Univ. of Coimbra, Março a Maio de 2001.

Festival Nacional de Robótica – Robótica 2001, Guimarães, Portugal, Abril de 2001.

12th International Meeting of the Euro Working Group on Decision Support Systems, Cascais, Portugal, May 2001.

Multi-Echelon Inventory Systems Conference, U.C. Berkeley, June 2001.

POMS-Brazil Conference, Guarujá, Brazil, August 2001.

Int. Workshop on Energy Minimization Methods in Computer Vision and Pattern Recognition, EMMCVPR'01, France

Statistical Signal Processing Workshop, Singapore, August 2001

FLAIRS'2001 Conference

Emotional and Intelligent II: The Tangled Knot of Social Cognition, 2001 AAAI Fall Symposium. AAAI, 2001

Symposium on Emotion, Cognition and Affective Computing (AISB Convention)

Fifth Multi-Conference on Systemics, Cybernetics and Informatics

International Joint Conference on Artificial Intelligence IJCAI 2001

3.6 SERVICE ACTIVITIES

This section is dedicated to service activities developed, during 2001, by ISR-Lisbon (ECE) researchers as members of the national and international scientific community.

3.6.1 EDITORIAL BOARDS

José Santos-Victor - Member of the Editorial Board of the Journal of Robotics and Autonomous Systems, Elsevier, until July 2001.

M. Isabel Ribeiro - member of the Editorial Board and of the Executive Board of the Robotic WEBook, an initiative of the European Robotics Research Network.

3.6.2 ADVISORY BOARDS

João José dos Santos Sentieiro - member of the European Space Agency (ESA) Advisory Group on Robotics and Automation.

M. Isabel Ribeiro – member of the IFAC Technical Committee on Intelligent Autonomous Vehicles.

Jorge S. Marques - Member of IAPR Governing Board.

António Pascoal – Member of the IFAC Technical Committee on Marine Systems.

António Pascoal – Member of the IFAC Technical Committee on Intelligent Autonomous Vehicles.

António Pascoal – Advisor , Italian Programme for Antartic Research.

3.6.3 PROGRAMME AND TECHNICAL COMMITTEES

José Santos-Victor – Member of the Programme Committee of the *International Symposium on Intelligent Robots and Systems,* Toulouse, France, July 2001.

José Santos-Victor – Member of the Programme Committee of the 2nd Intl. Workshop on Computer Vision Systems – ICVS, Vancouver, Canada, Jul. 2001.

José Santos-Victor – Member of the Programme Committee of the 4th European Workshop on Advanced Mobile Robots – EUROBOT, Lund, Suécia, Set. 2001.

Pedro M. U. A. Lima – member of the Executive Committee of the RoboCup Federation.

Pedro M. U. A. Lima – member of the Editorial Board of the *International Journal of Intelligent Control and Systems*, published by World Scientific Publ. Co.

Pedro M. U. A. Lima - member of the Editorial Board of the Portuguese *Robótica* magazine.

Pedro M. U. A. Lima – member of the Portuguese Technical-Scientific Commission of the *Festival Nacional de Robótica*

Pedro M. U. A. Lima – member of the International Program Committee of the *RoboCup 2001 Workshop*, Seattle, E.U.A., August

Pedro M. U. A. Lima – member of the International Program Committee of the *5th International Conference on Autonomous Agents 2001*, Montreal, Canadá, May.

Pedro M. U. A. Lima – member of the Organizing Committee of the *IEEE Mediterranean Conference on Robotics and Automation, MED'2002*, Lisboa, July 2002

M. Isabel Ribeiro_– member of the Organizing Committeee of the 10th Mediterranean Conference on Control and Automation, MED2002, Lisbon, Portugal, July 2002.

M. Isabel Ribeiro – member of Programme Committee of the 10th Portuguese Meeting on Graphical Compuatation, Lisbon, Portugal, October 2001.

M. Isabel Ribeiro – co-organizer of a Special Session on Cooperative Robotics on the European Control Conference-ECC 2001, Porto, Portugal, September 2001.

M. Isabel Ribeiro_ - member of the Programme Committee of the 1st Workshop on Robotics Education and Training, RET2001, Weingarten, Germany, July 2001.

M. Isabel Ribeiro - member of the Programme Committee of Robotica2001 – Festival Nacional de Robótica, Guimarães, Portugal, April 2001.

Sergio Jesus - European Conference on Underwater Acoustics, July 2000, Lyon, France.

Victor Barroso - Representive of the IEEE Signal Processing Soc. in the Working Group on New Wireless Publications.

Victor Barroso - Representive of the IEEE Signal Processing Soc. in the Steering Committee of the new Transactions on Mobile Computing.

Jorge S. Marques - Member of the Technical Committee of the Workshop on Pattern Recognition in Information Systems, IAPR, Setubal, Portugal, July 2001.

Jorge S. Marques - Member of the Simposium Iberoamericano de Reconhecimento de Padrões, Florianópolis, Brasil, 2001.

Isabel Lourtie - Associated member of the IEEE Sensor Array and Multichannel Technical Committee.

António Pascoal – Program Vice-Chair, 10th Mediterranean Conference on Control and Automation (MED2002), to be held in Lisbon, Portugal, July 2002.

António Pascoal – Member, International Program Committee, First International Workshop on Underwater Robotics for Sea Exploitation and Environmental Monitoring, Rio de Janeiro, Brazil, October 2001.

António Pascoal – Member, International Program Committee, 4th IFAC Symposium on Intelligent Autonomous Vehicles 2001 (IAV '01)", Sapporo, Japan, September 2001

António Pascoal – Member, International Program Committee, European Control Conference, ECC 2001, Porto, Portugal, September 2001.

António Pascoal – Member, International Program Committee, IFAC Conference CAMS´2001, Control Applications in Marine Systems, Glasgow, Scotland, July 2001.

António Pascoal – Member, International Program Committee, 9th Mediterranean Conference on Control and Automation, Dubrovnik, Croatia, June 2001.

3.6.4 CHAIRPERSON

João Sentieiro – Organizer and chair of the Session "Automation and Robotics" in the Congress Science and Technology of Spain and Portugal at the Turn of the Century, Lisbon, Portugal, Nov. 2001.

Pedro M. U. A. Lima - chair of middle-size league of RoboCup 2001, Seattle, USA, August 2001

Pedro M. U. A. Lima - co-chair of the *RoboCup 2002 Symposium*, Fukuoka, Japan, June 2002

M. Isabel Ribeiro - chair of a session at the European Control Conference, ECC'01, Porto, Portugal, September 2001.

Agostinho Rosa - Organization and co-chair of ACM SAC'01 - Artificial Intelligence and Computational Logic Track – Las Vegas - USA- March 2001.

Sergio Jesus - European Conference on Underwater Acoustics, July 2000, Lyon, France.

Sergio Jesus - OCEANS'00, MTS/IEEE, September 2000, Providence, Rhode Island, USA.

3.6.5 REVIEWERS

José Santos-Victor - International Symposium on Intelligent Robots and Systems, 2001.

José Santos-Victor - EUROBOT – Euromicro Workshop on Advanced Mobile Robots, 1997, 1999, 2001.

José Santos-Victor - MVA – Machine Vision and Applications, Springer.

José Santos-Victor - IEEE SMC - Transactions of systems Man and Cybernetics.

José Santos-Victor - IEEE PAMI – Transactions on Pattern Analysis and Machine Intelligence

Pedro M. U. A. Lima – IEEE Transactions on Robotics and Automation, IEEE Transactions on Fuzzy Systems, *Robótica,* RoboCup 2001 Workshop, 5th International Conference on Autonomous Agents 2001.

Paulo Tabuada - IEEE Control Systems Magazine, Hybrid Systems: Computation and Control Fourth International Workshop

Pedro M. U. A. Lima - reviewer of a Portuguese project on the development of innovative solutions for the shoe manufacturing industry, under the program FACAP, funded by the National Laboratory INETI.

M. Isabel Ribeiro – Machine Vision and Application Journal, 2001.

M. Isabel Ribeiro – IFAC World Congress, Barcelona, Spain, July 2002.

João Sequeira – European Control Conference, Porto, Portugal, 2001.

Luis Custódio - Symposium on Applied Computing,

Luis Custódio - International Conference on Autonomous Agents,

Luis Custódio - Conferência Científica e Tecnológica em Engenharia

Agostinho Rosa - Expert of EU Information Society Telematics Program – PE - TC

Agostinho Rosa - Reviewer of IEEE Transaction of Circuits and Systems for Video Technology.

Agostinho Rosa - Reviewer of IEEE Transaction of Biomedical Engineering

Agostinho Rosa - Reviewer of Clinical Neurphysiology

Agostinho Rosa - ACM SAC' 01 - Evolutionary Algorithms and Optimization – Las Vegas.

Agostinho Rosa - ICEIS 01 – Setúbal

Agostinho Rosa - ICANN 01 – Artificial Neural Networks – Vienna

Agostinho Rosa - IFAC 2001 – TC Optimal Control – Barcelona

Agostinho Rosa - SLEEP RESEARCH ONLINE 2001

Victor Barroso, João Xavier, João P. Gomes, Paulo M. Oliveira - IEEE Transactions on Signal Processing

Victor Barroso, João Xavier, João P. Gomes, Paulo M. Oliveira - IEEE Signal Processing Letters

Victor Barroso, João Xavier, João P. Gomes, Paulo M. Oliveira - IEEE Transactions on Circuits and Systems

António Pascoal - Reviewer of IEEE Transactions on Automatic Control

António Pascoal - Reviewer, IEEE Journal of Oceanic Engineering.

António Pascoal - Reviewer, Marine Technology Society Journal.

3.6.6 OTHER ACTIVITIES

João J. S. Sentieiro - member of the ICCTI bilateral actions evaluation panel.

João J. S. Sentieiro - member of the FCT grant evaluation panel.

José Santos-Victor – Evaluator of EU- Future Emerging Technologies (FET) R&D Project Proposals.

M. Isabel Ribeiro – co-responsible for the Interest Group on Cooperative Robotics of the EURON – European Robotics Research Network.

M. Isabel Ribeiro – participates in the activities of the key area on Education of the EUROBN-European Robotics Research Network. Co-proposer of the launching of a Robotic WEBook.

Jorge S. Marques - President of the Portuguese Association for Pattern Recognition (APRP).

Victor Barroso - Proposer (accepted) of the new IEEE Signal Processing Soc. Portuguese Chapter

António Pascoal - Member, Delegation of the Ministry of Science and Technology of Portugal to India, November 2001. Objective: to launch a program aimed at the interchange of researchers and joint work in the areas of Marine Science and Technology.

António Pascoal - Member, Work Group of Research Vessels, Ministry of Science and Technology of Portugal. Objective: to assess the state of the scientific fleet and to define guidelines for its expansion and efficient utilization by the scientific community at large.

3.7 ACADEMIC ACTIVITIES

Here we list the participation, during 2001, of ISR-Lisbon (ECE) researchers in committees for Master and Doctoral Thesis, and other academic related activities.

João Sentieiro - Member of the MSc Thesis Committee of Sjoerd van der Zwaan. "Vision Based Station Keeping and Docking for Floating Robots", IST, May 2001.

João Sentieiro - Member of the PhD Thesis Committee of César Augusto dos Santos Silva. "3D Motion and Dense Structure Estimation: Representations for Visual Perception and the Interpretation of Occlusions," IST, Maio 2001.

José Santos-Victor – Member of the MSc Thesis Committee of Sjoerd van der Zwaan. "Vision Based Station Keeping and Docking for Floating Robots", IST, May 2001. (Supervisor)

José Santos-Victor – Member of the "Provas de Aptidão Pedagógica e Capacidade Científica" of João Pedro Barreto. Faculdade de Ciências e Tecnologia, University of Coimbra., February 2001.

José Santos-Victor – Member of the PhD Thesis Committee of César Augusto dos Santos Silva. "3D Motion and Dense Structure Estimation: Representations for Visual Perception and the Interpretation of Occlusions," IST, Maio 2001. (ORIENTADOR)

Pedro M. U. A. Lima – member of the Doctoral Thesis committee of Tomasz Celinski, "Adaptive Control of Sensory Perception in Robotic Systems", The Australian National University, Australia.

M. Isabel Ribeiro - member of the M.Sc Thesis Committee of Carlos Alberto Fernandes da Silva Marques, IST, March 2001.

M. Isabel Ribeiro –member of the Doctoral Thesis Committee of Walter Jorge Mendes Vieira, Universidade Nova, May 2001.

M. Isabel Ribeiro – member of the Executive Board of Instituto Superior Técnico, with the responsibility of staff management, research project management and strategic planning. From Jan.01 to September.01.

M. Isabel Ribeiro – elected member of Assembleia de Representantes of IST, since September.01

Carlos Bispo – Member of the Committee of the M.Sc. thesis in Engineering Policy and Management of Technology, "Make-to-Stock vs. Make-to-Order in the Glass Manufacturing Industry," by Nuno Manuel Rosa dos Santos Órfão, Instituto Superior Técnico, technical University of Lisbon, February 2001.

Carlos Bispo – Member of the Committee of the M.Sc. thesis in Electrical and Computer Engineering, "Distributed Schedulin with Active Idleness: A key to the stabilization of multiclass queuing networks," by José António Alves Moreira, Instituto Superior Técnico, Technical University, June 2001.

Carlos Bispo – Member of the Committee for the equivalence of a Ph.D. thesis defended abroad in Technology, Management and Policy, "Local Content Requiremments and Industrial Development: Economic Analysis and Cost Modeling of the Automotive Supply Chain," by Francisco Veloso, Universidade Católica, Lisbon, September 2001.

Carlos Bispo – Member of the Committee of the M.Sc. thesis in Engineering Policy and Management of Technology, "Production Cost Modelling for the Automotive Industry," by António José Marques Monteiro, Instituto Superior Técnico, Technical University of Lisbon, December 2001.

Carlos Bispo – Member of the Committee of the Ph.D. thesis in Civil Engineering, "Widening the scope for bus priority with intermittent bus lanes," Baichuan Lu, Instituto Superior Técnico, Technical University of Lisbon, December 2001.

Carlos Bispo – Member of the Coordinating team for the Master of Science program on Engineering and Management of Technology at IST-UTL.

Sergio Jesus – Member of the PhD Thesis Committee of Orlando Camargo Rodriguez ,2001

Sergio Jesus – member of the PhD Thesis Committee of Francisco Garcia, Detecção Passiva de Sinais Transientes, IST, June 2001.

Sergio Jesus – Member of the M.Sc. Thesis Committee of Nelson Martins ,2001

Sergio Jesus – Member of the M.Sc. Thesis Committee of Cristiano Soares,2001

Victor Barroso - Vice President of the IST's Scientific Council for the Graduation Programs (since October)

Victor Barroso - Head of the Coordinating Committee of the Graduation Programs at IST's Dept. of Electrical and Computer Engineering

Jorge S. Marques - Coordinator of the Control and Robotics area of the Electrical Engineering undergraduate course at IST.

Pedro Aguiar - Member of the Scientific Committee of the IST ECE Graduate Education coordinator of the Systems, Decision, and Control area.

Isabel Lourtie - member of the PhD Thesis Committee of Francisco Garcia, Detecção Passiva de Sinais Transientes, IST, June 2001.

Isabel Lourtie - member of the MSc Thesis Committee of Carlos Pinto Coelho, Passive Constrained Rational Approximation for Frequency Domain System Identification, IST, May 2001.

Jorge S. Marques - member of the PhD Thesis Committee of Miguel Velhote Correia, Técnicas Computacionais na Percepção Visual do Movimento, Univ. of Porto, Dec 2001.

Jorge S. Marques - member of the PhD Thesis Committee of César Silva, 3D Motion and Dense Structure Estimation, IST, May 2001.

Jorge S. Marques - member of the PhD Thesis Committee of Francisco Garcia, Detecção Passiva de Sinais Transientes, IST, June 2001.

Jorge S. Marques - member of the PhD Thesis Committee of João Manuel Tavares, Análise de Movimento de Corpos Deformáveis usando Visão Computacional, Univ. of Porto, Jan 2001.

Jorge S. Marques - member of the MSc Thesis Committee of Rui de Jesus, Seguimento do Corpo Humano com Modelos Articulados Bidimensionais, IST, 2001.

Carlos Silvestre – Member of the MSc Thesis Committee of Sjoerd van der Zwaan. "Vision Based Station Keeping and Docking for Floating Robots", IST, May 2001.

António Pascoal – Member of the PhD Thesis Committee of Mikael Bliksted Larsen. "Autonomous Navigation of Underwater Vehicles," Department of Automation, Technical University of Denmark, February 2001.

António Pascoal – Member of the PhD Thesis Committee of Paulo Tabuada. "Hierarchies and Compositional Abstractions of Hybrid Systems," DEEC, IST, Lisbon, November 2001.

António Pascoal – Member of the PhD Thesis Committee of Aníbal Matos. "Condições de Optimalidade para Problemas de Optimização Dinâmica," FEUP, Porto, June 2001.

3.8 DISTINGUISHED VISITORS

Andre Quinquis - ENSIETA, Brest, France.

Andrew Gee - Engineering Department, University of Cambridge, UK

Anthony Healey – Department of Mechanical Engineering, Naval Postgraduate School, Monterey, California, USA.

Chiu, Ching-Sang - Naval Postgraduate School, Monterrey, USA.

Daniele Mortari - Universita degli Studi La Sapienza di Roma, Italy.

David Marco – Department of Mechanical Engineering, Naval Postgraduate School, Monterey, California, USA.

Dimitris Bertsimas - Sloan School of Management, Massachusetts Institute of Technology, USA.

Gerhard Kraetzschmar - University of Ulm, Germany.

Giles Celleux - INRIA Rhone-Alpes, France.

Giovanni Indiveri - German National Center on Information Technologies, Institute for Intelligent Autonomous Systems, GMD-AiS, Germany.

Henrik Christensen - Royal Institute of Technology, Stockholm, Sweden.

Isaac Kaminer – Department of Aeronautics and Astronautics, Naval Postgraduate School, Monterey, California, USA.

J.-P. Hermand - Universite Libre de Bruxelles, Bruxelles, Belgium.

Josiane Zerubia – INRIA, Shopia-Antipolis, France

Martin Siderius - Saclantcen Undersea Research Centre, La Spezia, Italy.

Mor Harchol-Balter - Computer Science Department, Carnegie Mellon University, USA.

Panos Antsaklis – Nôtre Dame University, Indiana, USA.

Richard Prager - Engineering Department, University of Cambridge, UK

3.9 SPECIAL EVENTS

3.9.1 NARVAL SEA TRIAL, Villefranche, Nice, France June 2001

Objective: During a test week the NARVAL underwater vehicle was operated at sea to test the following functionalities:

- Ability of building video mosaics of the sea-bottom in a robust manner.
- Ability of controlloing the underwater vehicle based on visual feedback.

The vehicle was operated at sea and the various sub-systems were tested. The participants were Instituto Superior Técnico, Centre National de Recherches Scientifiques, Thomson- Activités sous-marin, University of Genova.

3.9.2 Workshop INTIFANTE'2001, Faro, Portugal, 10-11 of May 2001

Objective : 1)to exchange results obtained on the data acquired during the INTIFANTE'00 sea trial.
2) to exhange data sets acquired by respective institutions.

Institutions : Instituto Hidrografico, CINTAL/Universidade do Algarve, ISR/Instituto Superior Tecnico, ENEA-Italy

Projects : ATOMS, INTIMATE, INFANTE and TOMPACO

Presentations : 10

Attendees : total ~17 including Brasil-1, Italy-1, ISR(Lisbon)-3, IH(Lisbon)-3, SiPLAB(Faro)-7, CIMA(Faro)-2

3.9.3 MONAZ SEA TRIAL, Faial Island, Azores, Portugal, August 6-15, 2001

Objective: During a period of 9 days a joint exercise was carried out by the Naval Postgraduate School, Monterey, CA (USA), the Institute for Systems and Robotics-pole of IST (PT), and the IMAR/DOP/Univ. Azores (PT) with the objective of testing the cooperative operation of the ARIES AUV (USA) and the DELFIM ASC (PT) at sea. The final tests took place off the coast of Faial, in a region where hydrothermalism venting activity is known to occur. The end of the exercise witnessed the operation of the two vehicles communicating via an acoustic modem while ARIES acquired images of the seabed. The exercise fostered the development of synergies among the different groups involved. At the same time, it served as a focal point for the development of complex logistic capabilities that involved two support ships and a speed boat.

3.10 AWARDS

"Feasible Formations of Multi-Agent Systems", Paulo Tabuada, George Pappas, Pedro Lima - finalist of the *Best Student Paper Award* of the *American Control Conference*, Arlington, VA, USA, June 2001

"Abstractions of Hamiltonian Control Systems", Paulo Tabuada and George J. Pappas – finalist of the *Best Student Paper Award* of the *40th IEEE Conference on Decision and Control*, Orlando, FL, USA, December 2001

3.11 PUBLICATIONS

A) M.Sc. THESES (11):

[1] **Pedro Miguel Mendes Guerreiro** , "Modelização da detecção visual," M.Sc. Thesis July 20th 2001 - Universidade do Algarve, Faro , Portugal

[2] **Roberto Celio Lau Lam** , "Alisamento adaptativo e redução de malhas triangulares," M.Sc. Thesis July 25th 2001 - Universidade do Algarve, Faro, Portugal

[3] **Ulrich Schnier** , "Faster isosurface extraction by marching cubes using run length encoded volume data," M.Sc. Thesis April 28th 2001-Collaboration Univ. of Magdeburg, Germany.

[4] **Pedro Francisco Manique Silva Moita**, "Concepção de um Sistema Pericial para Apoio aos Ouvintes de uma Fonoteca," MSc Thesis, Instituto Superior Técnico, March, 2001, Lisboa, Portugal.

[5] **Nelson Martins** , "A time-frequency approach to blind deconvolution in multipath underwater channels," MSc Thesis, November, 2001, Universidade do Algarve, Faro, Portugal.

[6] **Cristiano Soares** , "Matched-Field Processing: Acoustic focalization with data taken in a shallow water area of the Strait of Sicily," MSc Thesis, March, 2001, Universidade do Algarve, Faro, Portugal.

[7] **Sónia Marques**, "Small Satellites Attitude Determination Methods" MSc Thesis, Instituto Superior Técnico, May , 2001, Lisboa, Portugal.

[8] **Sjoerd van der Zwaan**, "Vision Based Station Keeping and Docking for Floating Robots," MSc Thesis, Instituto Superior Técnico , May 10th, 2001, Lisboa, Portugal.

[9] **Nuno Manuel Rosa dos Santos Órfão**, "Make-to-Stock vs. Make-to-Order in the Glass Manufacturing Industry," M.Sc. thesis in Engineering Policy and Management of Technology, IST-UTL, February 2001.

[10] **José António Alves Moreira**, Distributed Scheduling with Active Idleness: A key to the stabilization of multiclass queuing networks," M.Sc. thesis in Electrical and Computer Engineering, IST-UTL, June 2001.

[11] **Carlos Marques "**Multi-Sensor Navigation for Soccer Robots," MSc Thesis, March 2001- Instituto Superior Técnico, Lisboa, Portugal

B) Ph.D. THESES (3):

[12] **Orlando Camargo Rodriguez** , "Ocean Acoustic Tomography Applied to the Estimation of Internal Tides in the Continental Platform" Ph.D. Thesis, Universidade do Algarve , 2001, Algarve, Portugal.

[13] **César Silva** , " 3D Motion and Dense Structure Estimation: Representations for Visual Perception and the Interpretation of Occlusions," Ph.D. Thesis, Instituto Superior Técnico, May 10th 2001, Lisboa, Portugal.

[14] **Francisco Garcia , "** Detecção Passiva de Sinais Transientes " Ph.D. Thesis, Instituto Superior Técnico , June 2001, Lisboa, Portugal.

C) IN BOOCKS (5):

[15] **C. Marques, P. Lima,** "A Localization Method for a Soccer Robot Using a Vision-Based Omni-Directional Sensor", in RoboCup 2000 Book, Springer-Verlag, Berlin, 2001

[16] **van Deemter, J.H. and du Buf, J.M.H**. Line and edge detection by curvature-adaptive neural networks. Chapter 10 in: Plausible neural networks for biological modelling, J.E. Vos and H.A.K. Mastebroek (eds), Kluwer Academic, pp 219-239, 2001.

[17] **du Buf, J.M.H.** Introduction to modeling brightness perception. Chapter 2 in: Vision models and applications to image and video processing, C.J. van den Branden Lambrecht (ed.), Kluwer Academic, 2001.

[18] **du Buf, H. and Bayer, M.M.** , Automatic diatom identification. World Scientific, to be published spring 2002.

[19] **V. Barroso, J. Xavier, and J. Moura.** Blind Channel Identification and Source Separation in SDMA Systems. Invited article in chapter on Spatial Diversity and Source Estimation, in Antennas in Wireless Communications Handbook, Ed. Lal C. Godara, CRC Press, June 2001

D) IN INTERNATIONALS JOURNALS (22) :

[20] **Cristian Munteanu, Agostinho Rosa.** "Evolutionary Image Enhancement with User Behavior Modeling" – "Revised version". Applied Computing Review, Vol 3, Number 6, pp:8-14, July 2001, ACM Press.

[21] **C Carvalho, H Pereira, M Carmo-Fonseca, AC Rosa.** "Chromosomal dark G bands determine the spatial organization of α–satellite DNA in the nucleus". Molecular Biology of the Cell, Vol.12, pp 3563-3572, Nov 2001.

[22] **MG Terzano, L Parrino, R Chervin, S Chokroverty, C Guilleminault, M Hirshkowitz, M Mahowald, H Moldofsky, A Rosa, R Thomas, A Walters.** "Atlas, Rules and Recording Techniques for the Scoring of Cyclic Alternating Pattern (CAP) in Human Sleep". Sleep Medicine. November 2001.

[23] **DL Poyares, AC Rosa, C Guilleminault, U Koster,** "Heart Rate Variability during sleep-disordered breathing in UARS and OSAS subjects". Sleep, Vol 24, pp A272, 2001. (Abs)

[24] **P. Lima, A. Bonarini, C. Machado, F. Marchese, C. Marques, F. Ribeiro, D. Sorrenti,** "Omni-Directional Catadioptric Vision for Soccer Robots", in special issue on the EuroRoboCup of the Journal of Robotics and Autonomous Systems, Elsevier, Amesterdam, Vol 36, no 2, August 31, 2001

[25] **M. Asada, T. Balch, R. D'Andrea, M. Fujita, B. Hengst, G. Kraetzschmar, P. Lima, N. Lau, H. Lund, D. Polani, P. Scerri, S. Tadakoro, T. Weigel, G. Wyeth,** "RoboCup-2000: The Fourth Robotic Soccer World Championships", AI-Magazine, Vol. 22, No. 1, Spring 2001

[26] **H.-D. Burkhard, D. Duhaut, M. Fujita, P. Lima, R. Murphy, R. Rojas,"**Towards a Research Roadmap for RoboCup", IEEE Robotics and Automation Magazine, December 2001

[27] **P. Lima, T. Balch, M. Fujita, R. Rojas, M. Veloso, H. A. Yanco,** "The RoboCup 2001 Competitions and Conference: Report and Research Issues", IEEE Robotics and Automation Magazine, December 2001

[28] **Soares C.J., Siderius M. and Jesus S.M.,** "Matched-field processing source localization in the Strait of Sicily", accepted to Journal Acoust. Soc. America, to be published in 2002.

[29] **C. Silva, J. Santos-Victor,** "Motion from Occlusions," Robotics and Autonomous Systems, Elsevier, 35(3-4) Junho 2001.

[30] **N. Gracias, J. Santos-Victor,** "Trajectory Reconstruction with Uncertainty Estimation using Mosaic Registration," Robotics and Autonomous Systems, Elsevier, 35(3-4) Junho 2001.

[31] **S. Gadanho, J. Hallam,** "Emotion-triggered Learning in Autonomous Robot Control", in Cañamero, D., Numaoka, C., and Petta, P., editors, Grounding emotions in adaptive systems, an Special Issue of Cybernetics and Systems, vol 32(5), Taylor & Francis, 2001.

[32] **Carlos Bispo, Sridhar Tayur,** "Managing simple re-entrant flow lines: Theoretical foundation and experimental results," IIE Transactions, Vol. 33, No. 8, August 2001.

[33] **L. M. B. C. Campos, F. J. P. lau,** "On the convection of sound in inverse catenoidal nozzles", Journal of Sound and Vibration, volume 244, pages 195-209.

[34] **L. M. B. C. Campos,** "On some solutions of the extended confluent hypergeometric differential equation", Journal of Computational and Applied Mathematics, volume 137, pages 177-200.

[35] **L. M. B. C. Campos,** "On the probability of collision for aircraft with dissimilar position errors", Amer. Inst. Aeron. Astron. Journal of Aircraft, volume 38, pages 593 - 599.

[36] **L. M. B. C. CAMPOS & J.M.G. Marques** "On safety metrics related to aircraft separation" Journal of the Royal Institute of Navigation, Volume 55, pages 39-63.

[37] **I. Kaminer, A. Pascoal, W. Kang, O. Yakimenko.** "Applications of Nonlinear Filtering to Navigation System Design Using Passive Sensors". IEEE Transactions Aerospace and Electronic Systems , Vol. 37, N0. 1, January 2001, pp. 158-172.

[38] **Francisco Garcia, Isabel M. G. Lourtie, Jorge Buescu,** L^2(R) Nonstationary Processes and the Sampling Theorem, IEEE Signal Processing Letters, April 2001

[39] **Jorge S. Marques, João M. Lemos,** Optimal and Suboptimal Shape Tracking Based on Multiple Switched Dynamic Models, Image and Vision Computing, 539-550, June 2001.

[40] **J. Xavier, V. Barroso, e José M.F. Moura.** Closed Form Correlative Coding (CFC2) Based Blind Identification of MIMO Channels: An Isometry Fitting to Second Order Statistics. IEEE Trans. on Signal Processing, May 2001.

[41] **Pedro M. Q. Aguiar and José M. F. Moura,** Three-dimensional modeling from two-dimensional video, IEEE Transactions on Image Processing, vol. 10, no. 10,October 2001.

E) IN INTERNATIONAL CONFERENCES (78)

[42] **Carlos Fernandes, Rui Tavares, Cristian Munteanu, Agostinho Rosa**, "Assortative Mating in Genetic Algorithms: Vector Quantization Problems". Proc. ACM SAC 2001, Las Vegas, USA, pp 361-365.

[43] **Cristian Munteanu, Agostinho Rosa,** "Evolutionary Image Enhancement with User Behaviour Modeling". Proc. ACM SAC 2001, Las Vegas, USA, pp 316-320.

[44] **Cristian Munteanu, Agostinho Rosa,** "Evolving Order Statistics Filters for Image Enhancement". Proc ICANNGA 2001, pp 288-291, Prague, Check Republic.

[45] **Carlos Fernandes, Agostinho Rosa,** "A Study on Non-random Mating and Variable Population Size in Genetic Algorithms using Royal road Function". Proc. IEEE CEC 2001, Seoul, South Korea, pp:60-66. Prémio Jovem Investigador IEEE-ICEC.

[46] **A Grilo, A Caetano, A Rosa,** "Agent Based Artificial Immune System". Proc Gecco, LBP, pp 145-151, 2001.

[47] **RTavares, A Rosa**,"Biased Genotype Variation in Evolutionary Algorithms using Phenotype Information". Proc Gecco, LBP, pp 421-428, 2001.

[48] **Gong HongFei, Agostinho Rosa,** "Simulation of Olive Fly Development Using Artificial Life Technic". Proc. CIMCA 2001, pp 614-620, ISBN:0858898470.

[49] **Cristian Munteanu, Agostinho Rosa,** "Color Image Enhancement using Evolutionary Principles and Retinex Theory of Color Constancy". Proc Neural Networks and Signal Processing – Proceedings of XIth Workshop NNSP 2001; Softcover; ISBN 0-7803-7196-8; Product No.: TH8584-TBR, pp: 393-402.

[50] **A Grilo, A Caetano, A Rosa,** "Immune System Modeling through Adaptive Complex System Model". 6th Online World Conference on Soft Computing and Industrial Applications 2001-WSC6. Pap:043.

[51] **Agostinho Rosa, Nuno Lopes, Pedro Silva,** "Lift Control using Evolutionary Algorithm". Proc NTCC 2001, pp 221-226, HongKong, PR China.

[52] **P. Tabuada, G. J. Pappas and P. Lima,** "Hybrid abstractions: A search and rescue case study", in Proceedings of the European Control Conference, Porto, Portugal, September 2001

[53] **P. Tabuada, G. J. Pappas and P. Lima,** "Compositional Abstractions of Hybrid Control Systems", in Proceedings of the 40th IEEE Conference on Decision and Control, Orlando, FL, USA, December 2001

[54] **P. Tabuada, G. J. Pappas and P. Lima,** "Cyclic directed formations of multi-agent systems", in Proceedings of the European Control Conference, Porto, Portugal, September 2001

[55] **P. Tabuada and P. Lima,** "Position Tracking for Underactuated Rigid Bodies on SE(3)", in Proceedings of the 5th IFAC Symposium on Nonlinear Control Systems - NOLCOS'2001, Saint- Petersburg, RUSSIA, July 2001

[56] **C. Marques, P. Lima,** "Multi-Sensor Navigation for Soccer Robots", in Proceedings of RoboCup 2001 Workshop, Seattle, USA, 2002

[57] **P. Tabuada, G. J. Pappas and P. Lima,** "Feasible Formations of Multi-Agent Systems", in Proceedings of the American Control Conference, Arlington, VA, June 2001.

[58] **P. Tabuada, G. J. Pappas,** "Hybrid abstractions that preserve timed languages", in Hybrid Systems: Computation and Control, Fourth International Workshop, Rome, Italy, March 2001

[59] **P. Tabuada, G. J. Pappas,** "Abstractions of Hamiltonian Control Systems", in Proceedings of the 40th IEEE Conference on Decision and Control, Orlando, FL, December 2001

[60] **D. Milutinovic, P. Lima,** "Petri Net Models of Robotic Tasks", in Proceedings of 2002 IEEE International Conference on Robotics and Automation, Washington D.C., USA, May 2002

[61] **P. Tabuada, G. J. Pappas,** "Abstractions of Hamiltonian Control Systems", in Proceedings of the 40th IEEE Conference on Decision and Control, Orlando, FL, December 2001

[62] **Loke, R. and du Buf, J.M.H.** Highlighting pipelines offshore Norway: visualization and quantitative analisis. Proc. MTS/IEEE Conf. Oceans 2001, Honolulu (Hawaii), Nov 6-8, pp 2688-2695, 2001.

[63] **Bayer, M., Pullan, M., Mann, D., Juggins, S., Ciobanu, A., Santos, L., du Buf, H., Fischer, S., Bunke, H., Wilkinson, M., Roerdink, J., Pech-Pacheco, J., Cristobal, G., Cirimele, V. and Ludes, B.** ADIAC: Using computer vision technology for automatic diatom identification. Proc. 16th Int. Diatom Symp., A. Economou-Amilli (ed.), Univ. of Athens, Greece, pp 537-562, 2001.

[64] **Santos, L. and du Buf, H,** Improved grating and bar cell models. Proc. 7th Neural Computing in Psychology Worksh., Brighton, UK, Sept 17-19, 2001. To be published as a book chapter, World Scientific.

[65] **Bobinger, U. and du Buf, J.M.H,** Modeling detection thresholds of many different stimulus patterns. 25th European Conf. on Visual Perception, Glasgow, August, in prep.

[66] **Jesus S.M. and Soares C.,** "Broadband MFP: coherent vs. incoherent", MTS/IEEE Oceans 2001, Hawai, USA, November.

[67] **Soares C.J., Siderius M. and Jesus S.M.,** "MFP source localization in the Strait of Sicily", MTS/IEEE Oceans 2001, Hawai, USA, November.

[68] **Jesus S.M., Coelho E., Onofre J., Picco P., Soares C. and Lopes C.,** "The INTIFANTE'00 sea trial: preliminary source localization and ocean tomography data analysis", MTS/IEEE Oceans 2001, Hawai, USA, November.

[69] **Gervaise C., Quinquis A., and MARTINS N.,** ``Time-frequency approach to the study of underwater acoustic channel estimation and source reconstruction'', in Physics in Signal and Image Processing, Marseille, France, pp.300--5, January.

[70] **Niall Winters, J. Santos-Victor, "**Information Sampling for Optimal Image Data Selection", 9th International Symposium on Intelligent Robotic Systems - SIRS2001 - Toulouse, France, Julho 2001.

[71] **J. Gaspar, E. Grossmann, J. Santos-Victor,** "Interactive Reconstruction from an Omnidirectional Image", 9th International Symposium on Intelligent Robotic Systems - SIRS2001 - Toulouse, France, Julho 2001.

[72] **N. Winters, J. Gaspar, E. Grossmann, J. Santos-Victor, "**Experiments in Visual-Based Navigation with an Omnidirectional Camera", ICAR2001 Workshop on Omnidirectional Vision Applied to Robotic Orientation and Nondestructive Testing, Budapest, Hungary, Agosto 2001.

[73] **S. van der Zwaan, A. Bernardino, J. Santos-Victor,** "Vision based station keeping and docking for floating vehicles, - European Control conference", ECC2001, Porto, Portugal, Setembro 2001.

[74] **J. Santos-Victor,** "Visual Servoing of Cellular Robots, European Control Conference", ECC2001, Porto, Portugal Setembro 2001.

[75] **E. Grossmann, D. Ortin, J. Santos-Victor,** "Algebraic aspects of reconstruction of structured scenes from one or more views, British Machine Vision Conference " , BMVC2001, Manchester, England, Setembro 2001.

[76] **N. Winters, J. Santos-Victor,** "Information Sampling for Appearance based 3D Object Recognition and Pose Estimation" , Irish Machine Vision Conference, Maionooth, Ireland, Setembro 2001.

[77] **J. Santos-Victor, N. Gracias, S. van der Zwaan,** "Using vision for underwater robotics: video mosaics and station keeping!" , 1st International Workshop on Underwater robotics for Sea Exploitation and Environmental Monitoring, Rio de Janeiro, Brasil, Outubro 2001.

[78] **N. Winters, J. Santos-Victor,** "Visual Attention-Based Robot Navigation using Information Sampling", IEEE/RSJ Intl. Conference on Intelligent Robots and Systems IROS2001, Maui, Hawai, Outubro 2001.

[79] **N. Gracias, J. Santos-Victor,** "Underwater Mosaicing and Trajectory Reconstruction using Global Alignement ", IEEE OCEANS 2001, Honolulu, Novembro 2001.

[80] **S. van der Zwaan, J. Santos-Victor,** "Real-time Vision-based Station Keeping for Underwater Robots", - IEEE OCEANS 2001, Honolulu, Novembro 2001.

[81] **J. Santos-Victor, A. Bernardino,** "Vision-based Navigation, Environmental Representations and Imaging Geometries", 10th International Symposium of Robotics Research, ISRR'2001, Lorne, Victoria, Australia , 9-12 Novembro, 2001.

[82] **M. Maçãs, R. Ventura, and L. Custódio,** "DARE: an Emotion-based Agent Architecture", FLAIRS'2001 Conference, Key West, Florida, USA, 2001.

[83] **M. Maçãs, R. Ventura, L. Custódio and C. Pinto-Ferreira,** "Experiments with an Emotion-based Agent using the DARE architecture", Symposium on Emotion, Cognition and Affective Computing (AISB Convention), 2001.

[84] **P. Vale and L. Custódio,** "Learning Individual Basic Skills using an Emotion-based Architecture", Symposium on Emotion, Cognition and Affective Computing (AISB Convention), 2001.

[85] **R. Sadio, G. Tavares, R. Ventura and L. Custódio,** "An Emotion-based Agent Architecture Application with Real Robots", Emotional and Intelligent II: Tangled Knot of Social Cognition, AAAI Fall Symposium, 2001.

[86] **R. Ventura, L. Custódio and C. Pinto-Ferreira,** "Learning Courses of Action using the «movie-in-the-brain» Paradigm", Emotional and Intelligent II: Tangled Knot of Social Cognition, AAAI Fall Symposium, 2001.

[87] **J.Pais, and Carlos Pinto-Ferreira,** "NDProA: A Flexible Planner for Spatial Reasoning", Fifth Multi-Conference on Systemics, Cybernetics and Informatics, vol. 7, pp. 54—59, SCI2001, Orlando, USA.

[88] **Nuno Órfão, Carlos Bispo,** "An Inventory Decision Support System to the Glass Manufacturing Industry," 12th International Meeting of the Euro Working Group on Decision Support Systems, Cascais, Portugal, May 2001.

[89] **Carlos Bispo,** "Smooth Priorities for Make-to-Stock Inventory Control," Multi-echelon Inventory Systems Conference, U.C: Berkeley, U.S.A., June 2001.

[90] **Nuno Órfão, Carlos Bispo,** "Make-to-Stock vs. Make-to-Order in the Glass Manufacturing Industry," POMS-BRAZIL Conference, Guarujá, Brazil, August 2001.

[91] **João Sequeira, M. Isabel Ribeiro,** "A Negotiation Model for Cooperation Among Robots", Proceedings do European Control Conference (ECC'01), sessão especial sobre Robótica Cooperativa, Porto, Portugal, 2001.

[92] **M. Isabel Ribeiro, Jorge Dias, John Hallam,** "RoboticWEBook: an electronic book initiative", Proceedings do 1st Workshop on Robotics Education and Training, RET 2001, Weingarten, Alemanha, pp. 127-129, Julho de 2001.

[93] **L. M. B. C. Campos,** "On the calculation of collision probabilities as a contribution to safety metrics", CARE Innovative ATM Workshop, Eurocontrol, Brussels.[PARA]

[94] **L. M. B. C. Campos,** "On the calculation of safe separation distances between aircraft due to wake effects". 5th Wavenet Workshop on Wave turbulence and the airport environment, Deutsch Flugsicherung (DFS) Akadamie, Langen.[PARA]

[95] **L. M. B. C. Campos,** "On the coupling of magnetosonic and Alfven waves in an isothermal atmosphere under an uniform horizontal magnetic field", INTAS Workshop of MHD Waves in Astrophysical Plasmas, Palma de Maiorca.

[96] **P. Encarnação, A. Pascoal,** "Combined Trajectory Tracking and Path Following for Underwater Vehicles". Proc. IFAC Conference CAMS´2001, Control Applications in Marine Systems, Glasgow, Scotland, July 2001.

[97] **S. Rumyantzev, A. Miroshnikov, E. Popova,** "Design of PID controllers for ship course keeping using approximations to H_∞ solutions ". Proc. IFAC Conference CAMS´2001, Control Applications in Marine Systems, Glasgow, Scotland, July 2001.

[98] **M. Aicardi, G. Casalino, G. Indiveri, A. Aguiar, P. Encarnação, A. Pascoal,** "A Planar Path Following Controller for Underactuated Marine Vehicles". Proc. 9th Mediterranean Conference on Control and Automation", Dubrovnik, Croatia, June 2001.

[99] **P. Encarnação, A. Pascoal,** "Combined Trajectory Tracking and Path Following for Marine Vehicles ". Proc. 9th Mediterranean Conference on Control and Automation", Dubrovnik, Croatia, June 2001.

[100] **J Hespanha, O. Yakimenko, I. Kaminer, A. Pascoal,** "Stability and Performance Analysis of LPV Systems with Brief Instabilities". Proc. 9th Mediterranean Conference on Control and Automation", Dubrovnik, Croatia, June 2001.

[101] **A. Aguiar, A. Pascoal,** "Regulation of a Nonholonomic Autonomous Underwater Vehicle with Parametric Modeling Uncertainty using Lyapunov Functions ". Proc. 40th IEEE Conference on Decision and Control, Orlando, Florida, December 2001.

[102] **P. Encarnação, A. Pascoal,** "Combined Trajectory Tracking and Path Following: an Application to the Coordinated Control of Autonomous Marine Craft ". Proc. 40th IEEE Conference on Decision and Control, Orlando, Florida, December 2001.

[103] **J. Hespanha, O. Yakimenko, I. Kaminer, A. Pascoal,** "Linear Parametrically Varying Systems with Brief Instabilities: an Application to Integrated Vision / IMU Navigation ". Proc. 40th IEEE Conference on Decision and Control, Orlando, Florida, December 2001.

[104] **Francisco M. Garcia, Isabel M. G. Lourtie,** Multipath Detection of Stochastic Transient Signals, Statistical Signal Processing Workshop, Singapore, August 2001

[105] **Pedro M. Q. Aguiar and José M. F. Moura,** Image motion estimation - convergence and error analysis, IEEE International Conference on Image Processing ICIP01, Thessaloniki, Greece, October 2001.

[106] **Pedro M. Q. Aguiar and José M. F. Moura,** Maximum likelihood estimation of the template of a rigid moving object, Energy Minimization Methods in Computer Vision and Pattern Recognition, Sophia Antipolis, France, September 2001, number 2134 in Lectures Notes in Computer Science, Springer-Verlag.

[107] **Cristina Videira Lopes and Pedro M. Q. Aguiar,** Aerial acoustic communications, IEEE International Workshop on Applications of Signal Processing to Audio and Acoustics WASPAA01, New York, USA, October 2001.

[108] **João Sanches, Jorge S. Marques**, 3D Reconstruction from Log-Compressed Rayleigh Images, IEEE International Conference on Image Processing, Thessaloniki, October, 2001.

[109] **Jacinto Nascimento, Jorge S. Marques,** An Adaptive Potential for Robust Shape Estimation, British Machine Vision Conference, 343-352, Manchester, September, 2001.

[110] **Pedro M. Jorge, Arnaldo J. Abrantes, Jorge S. Marques,** Automatic Tracking of Multiple Pedestrians with Group Formation and Occlusions, IASTED International Conference on Visualization, Imaging and Image Processing, 613-618, Marbella, Spain, September, 2001.

[111] **Jacinto Nascimento, Jorge S. Marques,** Improving the Robustness of Parametric Shape Tracking with Switched Multiple Models, Pattern Recognition in Information Systems, A. Fred, A. Jain, eds, 50-58, Setúbal, July, 2001.

[112] **Arnaldo J. Abrantes, Jorge S. Marques,** Shape Tracking Using Centroid Based Methods, Third International Workshop on Energy Minimization Methods in Computer Vision and Pattern Recognition, 576-591, September, 2001.

[113] **João Sanches, Jorge S. Marques,** A Fast MAP Algorithm for 3D Ultrasound, Third International Workshop on Energy Minimization Methods in Computer Vision and Pattern Recognition, 63-74, September, 2001.

[114] **João Xavier, Victor Barroso.** Blind Identification of MIMO Channels Based on Correlative Coding: Performance Analysis. Proc. IEEE International Workshop on Signal Processing Advances for Wireless Communications, SPAWC'01, Taoyuan, Taiwan, R.O.C., March 2001.

[115] **João Xavier, Victor Barroso.** Performance Analysis of a Second-Order Statistics Based Solution for the MIMO Channel Identification Problem. Proc. IEEE International Conference on Acoustics, Speech and Signal Processing, ICASSP 2001, Salt Lake City, USA, 2001.

[116] **J. Xavier, V. Barroso.** Second-Order Blind MIMO Channel Identification Based On Correlative Coding: Asymptotic Performance Analysis. Proc. IEEE International Symposium on Information Theory, Washington D.C., USA, 2001.

[117] **João Gomes, Victor Barroso.** Wavefront segmentation in phase-conjugate arrays for spatially modulated acoustic communication. Proc. IEEE Conference on Oceanic Engineering, OCEANS 2001, Honolulu, Hawaii, USA, 2001.

[118] **João Gomes, Victor Barroso.** Equalization and coding for coherent communication in the ASIMOV vertical link. Proc. IEEE Conference on Oceanic Engineering, OCEANS 2001, Honolulu, Hawaii, USA, 2001.

[119] **Paulo M. Oliveira and Victor N. Barroso,"**Mutual relation between Instantaneous Frequency and Instantaneous Bandwidth", Proc. ISSPA 2001, Kuala Lumpur, Malasya, August 2001.

F) IN NATINAL JOURNALS (2) :

[120] **A. Vale, J. Simões, J. Machado, P. Lima,** "Navigation in a Maze", Robótica, nº 45-4º Trimestre, pp.66-70.

[121] **João Gomes-Mota, M. I. Ribeiro,** "RESOLV: da robótica à realidade virtual", Robótica, Novembro de 2001.

G) IN NATINAL CONFERENCES (1) :

[122] **Lam, R., Loke, R. and du Buf, H.** "Smoothing and reduction of triangle meshes." Proc. 10th Portuguese Computer Graphics Meeting, Lisbon, pp 97-105 (in Portuguese). 2001

H) TECHNICAL REPORTS (12) :

[123] **Rodriguez O.C.,** "Hydrodynamical Normal Mode Estimation on the INTIFANTE'00 data set", SiPLAB Rep. 04/01, November.

[124] **Corre V.,** ``Estimation of the Properties of a Range-Dependent Ocean Environment: a Simulation Study'', SiPLAB Rep 03/01, October.

[125] **Jesus S., Silva A. e Soares C.,** ``INTIFANTE'00 Sea Trial Data Report - Events I,II and III'', SiPLAB Rep 02/01, May.

[126] **Jesus S.,** ``Tomografia Passiva Costiera - Data Report, Phase 1'', SiPLAB Rep 01/01, March.

[127] **Jesus S. and Soares C,** ``Tomografia Passiva Costiera - Inversion results with active data - Phase 2'', SiPLAB Rep 06/01, December.

[128] **André Lourenço, Pedro Freitas, M. Isabel Ribeiro, Jorge S. Marques,** "Detection and Classification of Tridimensional Moving Objects", ISR Technical Report RT-601-01, December de 2001.

[129] **D. Soetanto, A. Pascoal,** "Path Following Control for a Nonholonomic Dynamic Mobile Robot with Parametric Modeling Uncertainties ". DSORL-ISR Technical Report, November 2001. To be submitted for publication.

[130] **D. Soetanto, A. Pascoal,** "Control of a Unicyle Type Wheeled Mobile Robot with Saturating Actuators ". DSORL-ISR Technical Report, December 2001. To be submitted for publication.

[131] **S. Rumyantzev, A. Pascoal, C. Silvestre,** "Acceleration Feedback for Hydrofoil Craft Control: a Gain Scheduling Framework". DSORL-ISR Technical Report, October 2001. To be submitted for publication.

[132] **P. Oliveira, A. Pascoal,** "Periodic and Multirate Filter Design using LMIs". DSORL-ISR Technical Report, October 2001. To be submitted for publication.

[133] **M. Prado, C. Silvestre, A. Pascoal,** "A Model for the DELFIM Autonomous Surface Craft: from Physical Principles to MATLAB Code". DSORL-ISR Technical Report, March 2001.

[134] **A. Healey, A. Pascoal,** "Hydro-Thermal Vent Mapping with Multiple Autonomous Vehicles: the AZORES 2001 Missions". NPS/DSORL-ISR Technical Report, October 2001.

3.12 SUBMITED PAPPERS

I) Ph.D. THESES (3):

[135] **Pedro Encarnação** , "Nonlinear Path Following Control Systems for Ocean Vehicles". Ph.D. Thesis, Instituto Superior Técnico, Lisboa, Portugal. Submitted April 2001.

[136] **António Aguiar**, "Nonlinear Motion Control of Nonholonomic and Underactuated Systems". Ph.D. Thesis, Instituto Superior Técnico, Lisboa, Portugal. Submitted June 2001.

[137] **Paulo Oliveira**, "Periodic and Nonlinear Estimators with Applications to the Navigation of Ocean Vehicles". Ph.D. Thesis, Instituto Superior Técnico, Lisboa, Portugal. Submitted September 2001.

J) CHAPTER OF BOOKS (2)

[138]**Agostinho C da Rosa, Dalva Poyares, Christian Guilleminault**. "Processamento de Sinais Electrofisiológicos para Detecção e Classificação Automática do Sono". In "Manual de Poligrafia do Sono". Edição da Assossiação Brasileira de Sono.

[139] **Gong HongFei, Agostinho Rosa.** "Simulation of Olive Fly Development Using Artificial Life Technic". In "Computational Intelligence and Control". M Mohammadian (Edt).

K) INTERNATIONAL JOURNALS (15)

[140] **D. Poyares, C. Guilleminault, A. Rosa.** "Sleep and EEG power spectrum in post encephalitis hypersomnia: a case report". Sleep Medicine.

[141] **Bernhard Obermaier, Cristi Munteanu, Gert Pfurtscheller, Agostinho Rosa,** "Assymetric Hidden Markov Model Classification of Movement Potentials". IEEE Trans. Systems, Man and Cybernetics.

[142] **Mario Giovanni TERZANO, Liborio PARRINO, Agostino ROSA, Vincenzo PALOMBA, Arianna SMERIERI.** "CAP And Arousals in the Structural Development of Sleep an Integrative Perspective", Sleep Medicine.

[143] **José António Alves Moreira, Carlos Bispo,** "Distributed Scheduling with Active Idleness: A key to the stabilization of multiclass queuing networks," Submitted to the IEEE Transactions on Automatic Control, February 2001.

[144] **Sérgio Guerreiro, João Sequeira,** "Business Modelling and Robot Control Architectures", submitted to the Journal of Robotics and Autonomous Systems, Elsevier.

[145] **L. M. B. C. Campos,** "On the derivation of asymptotic expansions for specialfunctions from the corresponding differential equations", Integral Transforms and Special Functions, (to appear, 25p).

[146] **L. M. B. C. Campos & P. J. S. Gil,** "On Alfven waves convected by a radial flow in a non-uniform magnetic field", Wave Motion, (to appear).

[147] **L. M. B. C. Campos & J.R.C. Azinheira,** "On the application of special functions to non-linear and unsteady stability", Part I: Method of interactive solution of coupled non-linear system", Integral Transforms and Special Functions, (to appear).

[148] **L. M. B. C. Campos & J.R.C. Azinheira,** "On the application of special functions to non-linear and unsteady stability", Part II: Solution in term of Bessel and hypergeometric functions. Integral Transforms and Special Functions, (to appear).

[149] **J. Hespanha, O. Yakimenko, I. Kaminer, A. Pascoal,** "Linear Parametrically Varying Systems with Brief Instabilities: an Application to Integrated Vision / IMU Navigation ". Submitted to IEEE Transactions on Control Systems Technology.

[150] **P. Tabuada, G. J. Pappas and P. Lima,** IEEE Transactions on Robotics and Automation, Special Issue on Multi-Agent Systems

[151] **C. Silvestre, A. Pascoal, I. Kaminer.** "On the Design of Gain-Scheduled Trajectory Tracking Controllers". Accepted for publication in the International Journal of Robust and Nonlinear Control, Special Issue on Gain-Scheduling. To appear in 2002.

[152] **Jacinto Nascimento, Jorge S. Marques,** Robust Multi-Model Filter for Shape Tracking in the Presence of Outliers, Pattern Recognition accepted.

[153] **João Sanches, Jorge S. Marques,** Joint Image Registration and Volume Reconstruction for 3D Ultrasound, Special Issue on Ultrasonic Image Processing and Analysis of Pattern Recognition Letters, accepted, 2002.

[154] **J.S. Marques, J.M. Lemos and A.J. Abrantes,** A HMM approach to the estimation of random trajectories on manifolds, Signal Processing, accepted.

L) INTERNATIONAL CONFERENCES (17)

[155] **Atila Neves, Osvaldo Brasao, Agostinho Rosa,** "Learning the Risk board Game with Classifier Systems". ACM SAC'02 – EA&O track.

[156] **Tito Silva, Agostinho Rosa,** "Visual Objects Representation using Features Network". WSES - ICJNN 02, Interlaken.

[157] **Cristian Munteanu, Agostinho Rosa,** "Adaptive Reservoir Genetic Algorithm: Convergence Analysis". WSES – EC 02, Interlaken .

[158] **Fernandes C, Caldeira JP, Rosa AC,** "Infected Genes Evolutionary Algorithm for School Timetabling", WSES –EC 02, Interlaken.

[159] **Tito Silva, Agostinho Rosa,** "Representation, Recognition and Reconstruction of Objects through a Features Network". Proc. IJCNN – WCCI – 2002, Honolulu, Hawaii.

[160] **A. Aguiar, A. Pascoal,** "Dynamic Positioning of an Underactuated AUV in the Presence of a Constant Unknown Current Disturbance". Accepted for presentation at the 15th IFAC World Congress, Barcelona, Spain, July 2002.

[161] **P. Encarnação, A. Pascoal,** "Combined Trajectory Tracking and Path Following Control for Dynamic Wheeled Mobile Robots ". Accepted for presentation at the 15th IFAC World Congress, Barcelona, Spain, July 2002.

[162] **P. Oliveira, A. Pascoal, I. Kaminer,** "A Nonlinear Vision Based Tracking System for Coordinated Control of Marine Vehicles ". Accepted for presentation at the 15th IFAC World Congress, Barcelona, Spain, July 2002.

[163] **A. Aguiar, A. Pascoal,** "Stabilization of an Underactuated Autonomous Underwater Vehicle Via Logic-Based Hybrid Control ". Accepted for presentation at MED2002 Conference, Lisbon, Portugal, July 2002.

[164] **A. Aguiar, A. Pascoal,** "Way-Point Tracking of Underactuated AUVs in the Presence of Ocean Currents". Accepted for presentation at MED2002 Conference, Lisbon, Portugal, July 2002.

[165] **A. Aguiar, A. Pascoal,** "Practical Stabilization of the Extended Nonholonomic Double Integrator". Accepted for presentation at MED2002 Conference, Lisbon, Portugal, July 2002.

[166] **R. Cunha, C. Silvestre, A. Pascoal,** "Path Following Controller for an Autonomous Helicopter". Accepted for presentation at MED2002 Conference, Lisbon, Portugal, July 2002.

[167] **L. Lapierre, D. Soetanto, A. Pascoal,** "Adaptive Nonlinear Vision Based Path Following Control of a Wheeled Robot ". Accepted for presentation at MED2002 Conference, Lisbon, Portugal, July 2002.

[168] **S. Rumyantzev,** "Algebraic disturbance feedback methods in hydrofoil craft control". Accepted for presentation at MED2002 Conference, Lisbon, Portugal, July 2002.

[169] **A. Aguiar, A. Pascoal,** "Global Stabilization of an Underactuated Autnomous Underwater Vehicle Via Logic-Based Switching". Submitted for presentation at the IEEE 2002 Conference on Decision and Control, USA, December 2002.

[170] **A. Aguiar, A. Pascoal,** "Dynamic Positioning and Way-Point Tracking of Underactuated AUVs in the Presence of Ocean Currents ". Submitted for presentation at the IEEE 2002 Conference on Decision and Control, USA, December 2002.

[171] **A. Aguiar, A. Pascoal,** "Practical Stabilization of the ENDI Under Input Saturation Constraints via Logic-Based Hybrid Control ". Submitted for presentation at the IEEE 2002 Conference on Decision and Control, USA, December 2002.

M) IN NATINAL CONFERENCES (2) :

[172] **Santos, L.M. and du Buf, J.M.H.** "Pattern detection using cortical cell models". Submitted to: 12th RECPAD (Portuguese pattern recogn. conf.), Aveiro, June 27-28.

[173] **Loke, R.E. and du Buf, J.M.H.** "Diatom contour classification by curvature of convex and concave segments. Submitted to: 12th RECPAD (Portuguese pattern recogn. conf.), Aveiro, June 27-28.

4.0 LABORATORY FACILITIES AND SERVICES

4.1 COMMON FACILITIES

ISR/IST has a computer network infra-structure based on 2 DEC Alpha servers and 7 DEC Alpha workstations. The Computing Center group runs also three Macintosh computers and 4 laser printers. More than 200 users have accounts on the isr.ist.utl.pt domain, and more than 100 machines, including PCs, SUN workstations, Macintoshes and others, are currently linked to the network.

4.2 LABORATORY FACILITIES

AIMS Lab

The AIMS Lab offers the following facilities:

7 PC - Pentium like

3 MAC computers (one portable)

1 LISP machine

1 Laser printer

1 Nomadic Super-Scout mobile robot, with on-board computer, vision camera and wireless ethernet.

3 Nomadic Super-Scout mobile robots, with on-board computer, vision camera and wireless ethernet (shared with te ICLab).

3 soccer player robots, built at ICLab, with differential drive kinematics, open control and guidance architecture based on a Pentium clone motherboard, with an on-board video-conference camera each (shared with ICLab).

MOBILE ROBOTICS Lab (LRM)

The LRM offers the main following facilities:

- 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.
- 2 Scout mobile platforms with on-board computer, vision camera and wireless Ethernet
- A 6 dof robot arm (GT 6A Robotique) installed on top the Robuter mobile platform.
- 3 Mb/s wireless Ethernet systems with two Access Points supporting roaming operation.
- 3 complete sets of the LEGO system for Mobile Robotics
- A Laser Range Finder from the Riegl supplier with range and luminance measurement.
- 2 Sick Laser Scanner.
- 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.

- Five Sun Workstations (2 Sparc Classic, 1 Sparc 5, 1 Sparc 20 with one processor, 1 Sparc 20 with two processors) with SunOs4.1.3. and Solaris 2.5 operating systems.

- 8 Pentium – class PCs, 1 Pentium II + 3 portable Pentiums. Four more PCs are available from external partners.

- Two laser printers, and one DeskJet colour printer.

- A large open space appropriate for mobile robotics navigation experiments.

INTELLIGENT CONTROL Lab (LCI)

The LCI offers the main following facilities:

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.

1 RWI ATRV-Jr mobile robot, 4-wheel drive, equipped with 16 sonars, GPS, inertial navigation module and a compass (shared with the AIMS, Mobile Robotics and 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 (shared with the AIMS Lab).

5 Philips 740K USB Web Cams, used in the soccer robots

5 WaveLan Wireless Ethernet PCMCIA boards.

9 Pentium Personal Computers – under Linux and Windows 98 OS.

1 Mobile Platform, built at LCI, 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.

2 Electrim optical RAMs**,** used for visual servoing applied to manipulators and mobile robots.

1 Space Mouse device, for teleoperation of mobile robots and manipulators.

1 Mobile Platform, built at LCI, with differential drive kinematics, 2*360W motors, open control and guidance architecture based on a i80486 motherboard.

3 soccer player robots, built at LCI, with differential drive kinematics, open control and guidance architecture based on a Pentium clone motherboard, with an on-board Philips web cam each.

COMPUTER VISION Lab (VISLAB)

The VisLab is equipped with various PCs , a DEC-Alpha Workstation, 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 a high-speed 4 degrees of freedom binocular head – Medusa - developed for research in active vision and a TRC LabMate mobile platform, two Nomad Superscout mobile platforms, equipped with vision and an on-board computer. Additionally various home-made small robots have been developed and are used for experiments in the areas of vision based control.

SIGNAL PROCESSING Lab (SP)

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 and implementation of modems for underwater acoustic data communications, the development of very low bit rate video compression algorithms for underwater acoustic transmission, and testing of navigation and guidance techniques for autonomous robotics.

- 3 Intel 486 personal computers
- 3 Intel Pentium personal computers
- 1 NeXT workstation
- 1 Hewlett-Packard LaserJet 4M printer
- 1 Hewlett-Packard OfficeJet Pro 1150C color inkjet printer/scanner
- 10 Mbit/s thin Ethernet LAN interfacing the Signal Processing Laboratory to the ISR Network
- 4 processor DEC2100 Alpha server and 10 workstations of various types including DEC Alphas, HP's and SGI's. It also has several PC's, b/w laser and wax colour printers.
- 1 Mini robot platform KHEPERA
- 1 ORCA underwater acoustic communication system
  - 1 surface modem
  - 1 programmable acoustic receiver
  - 1 underwater modem
- 1 Motorola software development system for the DSP56000 digital signal processor (DSP)
- 1 Motorola DSP96002 hardware/software DSP development system
- 2 Analog Devices SHARC ADSP21061 hardware/software DSP development systems
- 1 Xilinx field programmable gate array (FPGA) hardware/software development system
- 1 National Instruments PCI-MIO-16E-4 multifunction data acquisition board and LabView virtual instrumentation software
- 1 Matrox Rainbow Runner video capture board
- 1 TEAC CS-391 multichannel data recorder

- 1 Sony TCD-D3 portable digital audio tape (DAT) stereo recorder
- 1 Goldstar OS-9040D 40 MHz analog osciloscope
- 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

DYNAMICAL SYSTEMS AND OCEAN ROBOTICS LAB

1) DELFIM Prototype Autonomous Surface Vehicle (hull and propulsion system) - a small Catamaran (4m long) to carry out experimental research in the area of ocean robotics.

2) Pressure Chamber - to test the marinization of equipment down to depths of 600 meters.

3) Actuators and Sensors for Robotic Ocean Vehicle Development and Operation (part of the equipment will be installed in the new INFANTE AUV currently under construction)

- *Actuators* - 5 electrical thrusters.

- *Sensors* -
- 3 rate gyros, 2 pendulums and 1 fluxgate (Watson's Attitude & Heading Reference Unit AHRS-C303);
- 1 attitude reference unit (KVH).
- 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 Doppler Log TSM 5740 with 4 beams in a Janus configuration, operating at 300 KHz (Thomson-ASM);
- one 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 precise surface vehicle navigation - 1 Motorola Encore unit and 2 FREEWAVE radios.

4) 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.

- *Development System* - Microware FASTRAK development software running on a SUN-Workstation; professional OS9 for Gespac development systems.

- *Microcontroller Development System for the 8051 and 8051XA families.*

- *Graphics Station*: - 1 Silicon Graphics Indigo 2 Extreme.

- *MUCIS (MARIUS-User Command Interface System)* - a PC-based interface for vehicle tele-operation during sea trials.

- Local Area Network (LAN) consisting of CAN-bus interfaces and special boards for I/O and data processing. The Lav was entirelu designed at IST/ISR and will be installed on-board the underwater and surface vehicles currently under construction.

5) 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 MATRIXx. 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.

6) General Computer Facilities.

- 3 SUN Workstations
- 1 X-Terminal
- 6 Desktop PCs
- 3 Laptop PCs
- 1 Macintosh

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

AERONAUTICS GROUP

- Flight test laboratory - Instrumentation packages for Alpha Jet, A-7 and Aviocar, and calibration, and data processing equipment.
- Transfer of Flight Simulator from Delft University of Technology to IST.