Evaluation of the Institute for Systems and Robotics-at IST – ISR-IST
For the period 2008-2012
Conducted by the ISR/IST External Review Committee
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"The Institute for Systems and Robotics-at IST (ISR-IST) was founded in 1992. ... Research at ISR-IST spans a multitude of key topics, ranging from fundamental theoretical issues to the applications of engineering methods and tools to the design and analysis of complex systems. Across this broad spectrum our methodologies are rooted in solid mathematical principles, providing, whenever possible, formal guarantees of performance. ISR-IST is one of the R&D units of the Laboratory of Robotics and Systems in Engineering and Science (LARSyS), and most of its research matches the main objectives and the research plan of this national Associate Laboratory.[1]"

ISR's thematic interests span a very broad spectrum of topics ranging from Dynamical Systems and Control Theory to Land and Undersea Robots. The research themes are timely and important; the groups are well balanced between well-established and young, energetic and productive researchers. The researchers have significant presence on the international scene through their strong journal publication records, conference participation and established international collaborations. The senior members of the group are active participants in professional organizations and review panels, such as those organized by the National Science Foundation, USA. Furthermore, the researchers have established (and maintained) strong relationships with premier groups abroad, and have ongoing collaborations with colleagues in the US at Carnegie Mellon University, the University of Wisconsin, Madison and numerous European and Asian sites including École Polytechnique Fédérale de Lausanne, the University of Edinburg, UK, the University Jaume Primero, Castellon, Valencia, SP, the University of Girona, Girona, SP, Jacobs University, Bremen, GR, the Universities of Genoa, Pisa, Ancona, and Cassino, Lecce, Italy, IFREMER National Research Centre, Toulouse, FR, CMRE (previously NURC) international research Centre, LaSpezia, Italy, CNR-ISSIA (National Council of Research of Italy), Bari, Italy, the University of Zagreb, Croatia, the University of Tallin, Estonia, the Indian Institute of Technology, India, and the University of Macao, Macao to name just a few. The Institute also has a strong track record of both domestic and international funding.

The Institute has attracted very talented post-docs and graduate students, both nationally and internationally, who upon graduation have successfully pursued both academic and entrepreneurial careers. The success of the latter group is well documented through the existence of five successful spin-offs. Yet another important contribution of the Institute has been though well-established outreach activities aiming at using ever-popular robotics to attract pre-college students to engineering and research.

The Institute consists of five research groups – the Computer and Robot Vision Lab (VisLab), Dynamic Systems and Ocean Robotic Group (DSOR), Intelligent Robots and Systems Group (IRSg), Evolutionary Systems and Biomedical Engineer Lab (LaSEEB), and, the Signal and Image Processing Group (SIPg) -

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[1] BrochuraISR_Final, pages 1 and 2

dealing with a host of cognate problems.[2] The groups range in size from 3 faculty/post docs/collaborators and 10 graduate students (LaSEEB) to 20 faculty/post docs/collaborators and 13 graduate students (SIPg).

Computer and Robot Vision Lab (VisLab) develops methods and software for robotic vision applications. The team is focusing on problems of active vision, motion analysis, and visual based control. Most recently, VisLab researchers have developed the head of the open-source iCub robot (the most sophisticated robot worldwide in terms of motion degrees of freedom), as well as the methods and software for visuo-motor coordination, attention, reaching and imitation. The research team is very active internationally, as evidenced by their participation in 8 EU projects (RobotCub, Handle, DICORES, FIRST-MM, ROBOSOM, Poeticon+, CONTACT and URUS) during the last 5 years. The VisLab researchers have played a central role in these multidisciplinary projects and have extensively published their findings in prestigious journals and reported the latest development in international conferences.

Dynamic Systems and Ocean Robotic Group (DSOR) focuses on the development of advanced robotic vehicles including surface and underwater robots, as well as aerial vehicles. The research team is recognized internationally for its theoretical and methodological contributions, validated by field trials. Their work supports team cooperative navigation and distributed coordination and control which are typically implemented within severe communication constraints in the underwater environment. The group has participated in many of the leading national and EU funded projects devoted to ocean exploration. The group has also built an excellent experimental infrastructure (laboratories and workshops) and has access to a wide set of autonomous marine and air vehicles to carry out field trials. Particularly impressive is a fleet of 5 surface and underwater autonomous vehicles which are extensively used in sea trials within the scope of different EU funded projects. In addition, the group is paving the way for technology transfer by building two vehicles of the MEDUSA-class to be delivered to the Technical University of Illmenau, Germany.

The group is active internationally and cooperates with a vast network of international partners from Europe, India, China, USA, and Japan. The record of international journal and conference publication is noteworthy; as well as the number of trained Ph.D. students, most of whom are now occupying leading positions in important European research institutions and industry, e.g., Duarte Antunes, Assistant Professor University of Eindhoven, Holland, Jose M. F. Vasconcelos, Deimos Engineering, Portugal and Vahid Hassani, MARINTEK, Norway.

Intelligent Robots and Systems Group (IRSg) Current research focus includes the topic of cooperation and the merging of artificial intelligence approaches with formal approaches in systems and control theory and operational research. The Intelligent Robots and Systems Group has produced high quality work in many areas, with each professor averaging between 1500 and 2500 citations. In particular, it is worth noting that this group has done pioneering work in (a) multi agent coordination with a theoretical basis in formal specifications and linear temporal logic, and applications to multi robot soccer and formation control; (b) multi robot control with communication controls; (c) estimation, control and navigation of underwater control vehicles; and, (d) rigorous, systems-theoretic approaches to under actuated systems. Currently the group is leading/coordinating two European Commission FP7 projects, *Robot Competitions Kick Innovation in Cognitive Systems and Robotics* and *Multi-Robot Cognitive Systems Operating in Hospitals.*

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[2] For informative overviews of their research themes and centers, see pages 6-31 and 32-37 in BrochuralSR_Final.

IRSg also has a strong record in training students who are emerging as leaders in academia and in industry. For example, Paulo Tabuada is now a professor at UCLA and is a leader in cyberphysical systems, specifically, event-triggered real-time systems. Dejan Milutinović, now Assistant Professor at UC Santa Cruz, is now known for his work on stochastic modeling of multi robot systems.

The Evolutionary Systems and Biomedical Engineering group (LaSEEB) divides its efforts between biomedical topics, including sleep, cognition and computational neuroscience, and bio-inspired optimization. While the primary focus is on applications in medicine, the group also works on applications in agriculture, energy and biology. They have publications in basic research (e.g., J. Cell Biology, J. Molecular Biology of the Cell), clinical applications (e.g., J. Sleep Medicine, J. Electroencephalography and Clinical Neurophysiology) and applications to computing and robotics (e.g., Evolutionary Computation, Artificial Neural Networks, Systems, Man, and Cybernetics, Applied Computing). Their most recent publications appeared in Neuroimage and the International Journal of Psychophysiology. In addition, their established collaboration with EPFL through a joint doctoral initiative has already resulted in a publication in Magnetic Resonance Imaging.

The Signal and Image Processing group (SIPg) divides its efforts between fundamental and application driven research. Their foundational work focuses on the development of the fundamental theory of signal processing on manifolds. This is a very timely albeit important direction given the impact that manifold learning and other derivatives of compressed sensing have had and will likely have on contemporary machine learning applications and "big data." The pioneering work of Xavier, Barroso and Moura, where the manifolds they employed were Riemannian, was essential in revealing the utility/power of working in these more general non-linear spaces. The application driven research includes contemporary topics of Sensor Networks, Underwater Acoustics, Image and Video Analysis, and Biomedical Engineering. In the general area of underwater acoustics, SIPg researchers have recently developed an *entire framework (algorithms and hardware)* that enables an underwater networking infrastructure (internet inside the ocean).

In addition to a prolific publication record during the time period under review, SIPg researchers have also been the recipients of a host of best paper/international awards in cognate areas such as image processing, linear algebra and machine vision. Finally, SIPg PhD student Pinar Oguz Ekim, advised by Prof. Joao Pedro Gomes, won the coveted 2013 IBM (Portugal) Science Prize (http://www.ibm.com/news/pt/pt/2013/05/28/z819028k68743182.html).[3]

Summary of Findings

ISR-at IST represents an extraordinary group of researchers and educators that are unique in their mission of bringing together system science, computational tools and applications and their expertise that spans basic science and large-scale field experiments. The institute has gained strong international visibility through extensive collaborations with premier research groups worldwide. During the last five years they have sustained an impressive publication record coupled with application driven development and field tests. The institute continues to attract excellent graduate students and post-docs who, upon graduation, become leaders in their own fields. The ISR culture continues to embrace strong public outreach programs and, more recently, active tech transfer and the launching of spin-offs.

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[3] For more than 20 years, this prize is the most prestigious award in Portugal in the areas of Engineering and Computer Science and is awarded to young researchers (usually their PhD thesis). This is the *fourth* IBM prize won by SIPg researchers.

The committee is very impressed with the achievements of ISR-Lisbon during the past five years, and strongly supports continuation of funding to support their core activities and their unique human and physical infrastructure.

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