TRAINING 1

19 - 20 July 2016
Consiglio Nazionalle delle Ricerche

LABUST
LABORATORY FOR UNDERWATER
SYSTEMS AND TECHNOLOGIES

Consiglio
Nazionale
delle
Ricerche
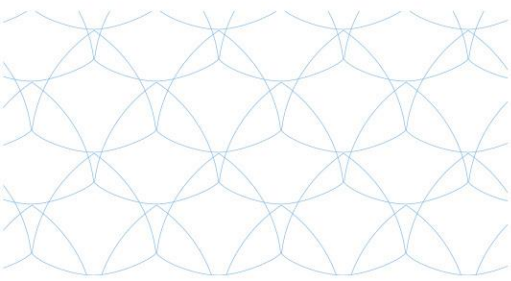
UNIVERSITY
of
LIMERICK
OLLSCOIL LUIMNIGH

Universitat de Girona
Institut de Recerca en Visió
per Computador i Robòtica

GIRONA UNDERWATER
VISION AND ROBOTICS

1. VENUE

CNR Research Area in Genoa - Sala Leonardo, 11th floor
Address: Via De Marini 6, 16149 Genoa, Italy

2. SCHEDULE

Day 1: 19 July 2016 (Tuesday) - How to build an Unmanned Marine Vehicle

09:15 - 10:00	**Mechanical design and construction** by Angelo Odetti
10:00 - 10:45	**Hw/Sw design & implementation – part 1** by Andrea Ranieri
10:45 - 11:15	BREAK
11:15 - 12:00	**Hw/Sw design & implementation – part 2** by Andrea Ranieri
12:00 - 14:00	LUNCH BREAK
14:00 - 16:00	**Visit to CNR-ISSIA Marine Robotics laboratory** Giorgio Bruzzone, Mauro Giacopelli, Edoardo Spirandelli

Day 2: 20 July 2016 (Wednesday) - Cooperative control and perception for heterogeneous Unmanned Marine Vehicles

09:15 - 10:45	**Cooperative guidance and mission control** by Marco Bibuli, Donato Di Paola, Antonio Petitti
10:45 - 11:15	BREAK
11:15 - 12:45	**Cooperative perception and environment characterisation** by Annalisa Milella, Rosalia Maglietta
12:45 - 14:15	LUNCH BREAK
14:15 - 15:15	**Human-robot interaction languages** by Davide Chiarella
15:15 - 15:45	BREAK
15:45 - 16:45	**Use of UAVs for ecosystem monitoring** by Massimo Ianigro, Roberto Colella

3. LECTURE DESCRIPTION

1. **Mechanical design and construction**
   This lecture will outline the basis of the design of an unmanned marine vehicle from a naval, mechanical and structural point of view. There will be an overview of the existing vehicles and the future ones with their peculiarities and requirements. It will be summarised the process of choice of right components and design of new ones with a specific focus on the choice of propellers and of the adequate propulsion system.

2. **Hw/Sw design & implementation – part 1-2**
   A brief introduction to the hardware and software design of marine robots will be given in this lecture. The robot's electronic hardware design have a huge impact on the reliability, efficiency and modularity of a marine robotic vehicle. However, the hardware design is an arduous process, often lacking "written rules" where many requirement and conditions must be satisfied at the same time. These requirements are, in turn, often based on the mechanical structure design and the electric design of the vehicle, where space and power constraints greatly reduce the available choices. Again, electronic hardware design reflects on software design, requiring efficiency in choosing the languages, and in designing and writing the code. In the last few years, thanks to the rapid development of fast, cheap, and power-efficient CPUs enclosed in small packages, many of the limiting factors imposed on robot's software by hardware design, have been relaxed. This has given developers some more chances to focus on code modularity and maintainability. Today, using advanced libraries and open-source frameworks developed by the community, is somehow truly possible to implement concepts such as information hiding and software reuse at higher levels, thus really providing an advancement in the world of software development.

3. **Cooperative guidance and mission control**
   This lecture will be focused on cooperative control of teams of unmanned vehicles, articulated along two dimensions: cooperative guidance and cooperative mission planning and control. In particular for the guidance aspects, the concept of virtual-target based path-following is extended to achieve the task of motion coordination among a team of unmanned robotic platforms. On the other hand, the cooperative mission planning and control aspects will cover mission re-planning strategies, decentralized task allocation algorithms, and mission execution control methodologies.

4. Cooperative perception and environment characterisation

Autonomous driving is a challenging problem, particularly when the domain is unstructured, as in an outdoor setting. Therefore, advanced perception systems are required to sense and understand the surrounding environment in order to recognize artificial and natural structures, topology, vegetation and paths. Due to the variety of situations that may be encountered, no sensor modality exists that can ensure reliable results in every case. Thus, a complementary sensor suite should be used to obtain the best performance.

Cooperative perception from multiple vehicles would further improve the results. This lecture will be focused on perception systems and methods for ambient awareness of mobile robots in field applications. First, an overview of the main sensor devices for autonomous navigation in unstructured environments will be presented, with a special focus on visual sensors. Then, some of the state-of-the-art techniques for robot localization and mapping, and their applications in different contexts will be reviewed. Recent advances from single robot to cooperative perception systems will be presented.   Scene understanding has been one of the main goals of computer vision for decades. Recently, the application of machine learning has given rise to new interest in this field, making it possible to capture new environmental properties from highly complex and dynamic scenes. Machine learning techniques enable to turn data into knowledge. Classification problems and some computational and statistical learning theories will be discussed with attention to the computer vision and robotics domains. Statistical methods for image processing, analysis and understanding can result in a final decision of the robot, with the development of fully automatic systems based on the integration of robotics and image analysis.

5. Human-robot interaction languages

This lecture will focus on Human–Robot Interaction (HRI) languages. The lecture will describe the different kind of interaction and communication between a human and a robot. In particular, the creation of a gesture-based language for underwater environment, which extends the one already used for diving, will be described: the choice of alphabet, syntax, semantics and communication protocol with error handling will be investigated.

6. Use of UAVs for ecosystem monitoring

In this lecture both technological and operational aspects of UAV will be outlined together with the more promising and challenging fields of application. The lecture will give an introductory overview of UAV technologies, with respect to their main components (frame, propellers, flight control unit, power, sensors, flight control unit, communication, safety and regulatory aspects, ground control station, …).

After this overview, will follow a presentation about the integration of UAV in real-world scenarios, related to projects carried out by the Field and Interaction Robotics Group at ISSIA, together with some of the experimental results achieved, including some aspects related to the marsupial sea-air systems.

4. DESCRIPTION OF THE PARTNER INSTITUTION

National Research Council of Italy

The CNR is a public organization with a duty to carry out, promote, transfer and improve research activities. CNR is distributed all over Italy through a network of institutes aiming at promoting its competences and at facilitating contacts and cooperation with local firms and organizations. The Institute of Studies on Intelligent Systems for Automation (CNR- ISSIA) focuses its research on topics as robotics, automation, signal and image processing, measurement and decision support systems based on soft-computing techniques for complex applications. CNR-ISSIA has particular experience in the development of unmanned marine vehicles for observation, sampling, exploration and protection application, as well as in acoustic and imagery data fusion and analysis for environment modeling and multi-dimensional reconstruction.

CNR-ISSIA has almost twenty years of research experience in the field of marine robotics, supported by the development of Remotely Operated Vehicles, Unmanned Surface Vehicles and underwater manipulators such as: Roby (1990-1992); Roby2 (1992-1997), an ROV with depth rating of 200 m, currently exhibited at the National Museum of Antarctica in Genova; Romeo (1997-today), a high manoeuvrability ROV with depth rating of 500 m; Charlie (2003-today), an unmanned catamaran originally designed for sampling sea surface microlayer; ALANIS (2008-today), an unmanned RIB-like vessel designed for the monitoring of coastal areas; AMADEUS work-cell, consisting of a couple of 7 degrees of freedom electro-mechanical underwater manipulators (EC Project AMADEUS - Advanced manipulation for deep underwater sampling, 1997-'99). These robots were exploited in scientific campaigns in Antarctica, Arctic and Mediterranean, validating different operational conditions of remote control, including satellite Internet-based tele-operation. Among other topics, research activity is focused on optical and acoustic motion estimation, development of specific devices, and cooperative control of teams of vehicles. CNR- ISSIA was partner of the EC FP7 Innovative Product Concepts project MINOAS - Marine INspection rObotic Assistant System, for the development of a vessel-inspection system based on multiple cooperative vehicles and virtual reality; EC FP7-SME CART - Cooperative Autonomous Robotic Towing system, a robotized system for the recovery of the towing line of distressed vessels. CNR is currently partner of the EC FP7-ICT MORPH - Marine robotic system of self-organizing logically linked physical nodes, a new concept for cooperative UMVs; the EC FP7 Collaborative Project CADDY - Cooperative autonomous diving buddy, for the diver operations support by means of cooperative robotic platforms. CNR is coordinator of the Italian Flagship Project RITMARE focused on research activities related to marine and maritime science and technologies. CNR is partner of the Italian project MARIS - Marine Autonomous Robotics for InterventionS, focused on cooperative underwater mobile manipulation.

5. BIOGRAPHIES OF LECTURERS

Angelo Odetti

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Angelo Odetti, Marine Engineer and Naval Architect (MSc)
He worked for Hovertech Ltd in FP7 project "HoverSpill, MultiEnvironment Air Cushion Oil Spill Fast Response & Post Emergency Remediation System" as lead engineer. He was responsible for technical project and design of MACP, a second generation of Air Cuschion Vehicles. He was in charge of developing new concepts for working-Hovercrafts technology. He owns two patents related to Hovercraft technology. In July 2013 he joined the CNR-ISSIA as a research fellow. He has worked on the project "Study of methodologies for modelling, identification and control of hovercraft" as part of the research program "Technologies and methodologies for monitoring of wetlands and shallow water in coastal area". From 2014 he started working on the concept development of new marine autonomous vehicle. He is designer of the structural and mechanical components of the two ROV: e-URoPe and P2ROV. He is working on mechanical and naval design of different components for autonomous vehicles.

Andrea Ranieri

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Andrea Ranieri received the M.Sc. Degree in Computer Engineering from the University of Genova in 2006 and the Ph.D. in Space Science and Engineering in 2012. Currently he is researcher at the Institute of Intelligent Systems for Automation (ISSIA) in Genova, within the National Research Council of Italy (CNR). His academic education had a strong focus on future networking and distributed systems, concepts that he's currently trying to apply to real-time systems, robotics and automation. He participated in several EC-funded projects as well as National projects. One of his main activities at ISSIA has been to provide technology transfer towards Small and Medium-Scale Enterprises (SME), mainly through the development and engineering of real-time Linux-based platforms for robotics and automation. He is also network and system administrator for the ISSIA unit of Genova. His technical background is extremely diverse with ten years' experience working with Linux in almost all of its main flavours and excellent programming skills, both with traditional languages such as C/C++ and scripting languages. He is a strong supporter of free open-source software that runs on top of off-the-shelf hardware.

Marco Bibuli

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Marco Bibuli (MSc 2005, PhD 2010) is researcher at the CNR-ISSIA, focusing his research activity on the design and development of navigation, guidance and control algorithms for unmanned marine vehicles and software architectures for supervision and mission control. He was task leader in the EC-funded project "Marine INspectionrObotic Assistant System" (2009-2012). He is currently Scientific Responsible for CNR and work-package leader within the scope of the EC FP7 CADDY project, Responsible of the action S5-WP6-A2 in the Italian Flagship Project RITMARE and has the role of Exhibit Co-Chair for the organization of the MTS/IEEE Oceans'15 Genova Conference. He is collaborating with several national and international universities and research institutions. He is the author of about 50 papers in journals and international conferences.

Antonio Petitti

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Antonio Petitti (S'12–M'16) received the B.S. and M.S. (Laurea Specialistica) degrees (summa cum laude) in automation engineering from Politecnico di Bari, Italy, in 2008 and 2010, respectively. Since 2011, he is Research Assistant at the Institute of Intelligent Systems for Automation (ISSIA) of the Italian National Research Council (CNR), Italy. In 2015, he received the Ph.D. degree in electrical and information engineering at Politecnico di Bari, Italy, and the joint Ph.D. degree of high qualification Scuola Interpolitecnica di Dottorato in information and communication technologies. Under the high qualification programme, in 2013 he has been Visiting Research Fellow at Autonomous Robotics and Human Machine Systems group at Max Planck Institute for Biological Cybernetics, Tübingen, Germany, and in 2014 he has been Visiting Research Fellow at Robotics and Interactions group at Laboratory for Analysis and Architecture of Systems (LAAS), Centre National de la Recherche Scientifique (CNRS), Toulouse, France. His scientific interests are focused on consensus theory and applications, distributed estimation, modeling and control of robotic networks.

Donato Di Paola

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Donato Di Paola received the M.S. degree (Laurea degree) in computer engineering and the Ph.D. degree in electrical engineering from the Politecnico di Bari, Bari, Italy, in 2007 and 2011, respectively.
From 2007 to 2011, he was a Research Associate with the Institute of Intelligent Systems for Automation (ISSIA) at the italian National Research Council (CNR), Bari, Italy. In 2012 he was Postdoctoral Associate at Department of Informatics and Automation, Università degli Studi Roma Tre, Roma, Italy. He was Visiting Scientist at Department of Aeronautics and Astronautics, Massachusetts Institute of Technology (MIT), Cambridge (MA), USA, in 2010 and Visiting Researcher at the Department of Computer Science, Boston University, Boston (MA), USA in 2013. He is currently Research Scientist at the institute ISSIA, National Research Council (CNR), Bari, Italy.

Rosalia Maglietta

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Rosalia Maglietta is researcher at the Institute of Intelligent Systems for Automation, National Research Council since 2007. She received bachelor's degree (2002) in Physics with full marks, Postgraduate Master Degree (2003) in Remote Sensing and PhD (2009) in Physics from the University of Bari. She is co-author of 52 papers in international journals and conference. She is a member of the editorial board of the Computational Biology Journal and works as reviewer for many international journal and conferences. She participated as co-investigator of ISSIA-CNR in many scientific projects. Her main research interests are in the fields of machine learning and data mining. Research topics include design and development of strategies for supervised and unsupervised learning, developing algorithms for 3D images segmentation, future extraction, learning models for imbalanced and big data, bioinformatics, computational biology, and robotic systems.

Annalisa Milella

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Annalisa Milella received the Laurea (summa cum laude) and the Research Doctorate degrees from the Politecnico of Bari, Italy, in 2002 and 2006, respectively, both in Mechanical Engineering. In 2005, for eight months, she was a visiting PhD student at the EPFL Autonomous Systems Laboratory. From 2006 to 2009, she worked as a Postdoctoral Researcher at the Institute of Intelligent Systems for Automation (ISSIA), National Research Council (CNR), Bari, Italy. Since December 2009, she has been a Researcher at ISSIA. In 2010, under the CNR's Short Term Mobility Program, she has started a scientific collaboration with the Australian Centre for Field Robotics, University of Sydney. In 2012, she has been involved in the project FP7 ERA-NET ICT-AGRI Ambient Awareness for Autonomous Agricultural Vehicles (QUAD-AV). Since January 2016, she has been principal investigator of the ISSIA research unit for the project FP7 ERA-NET ICT-AGRI 2 Simultaneous Safety and Surveying for Collaborative Agricultural Vehicles (S3-CAV). She is author of more than 50 publications on international journals, conference proceedings, and book chapters. She is reviewer of various international journals and conferences. She has taught academic courses and seminars in the field of applied mechanics, maintenance of mechanical systems, computer vision, and robot mechanics. Her main research interests include perception systems for mobile robot navigation in unstructured environments, computer vision applied to robotics and intelligent systems, agricultural robotics, robotic surveillance.
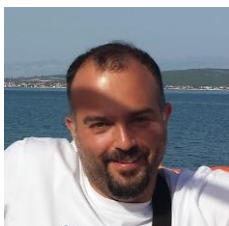
Davide Chiarella

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Davide Chiarella is a researcher of National Research Council, one of the most active research public organizations of Italy. He received a PhD degree in Information Technology and M.Sc. degree from the University of Genoa in 2010 and in 2005, respectively. His scientific career has diversified into different branches throughout the years. From 2006 to 2009 he carried out his research at the

Institute of Electronics and Information Engineering (CNR-IEIIT): his main research interest were intrusion detection, virus and worm detection, information security, data mining and knowledge discovery. He currently works for Institute of Intelligent Systems for Automation (CNR-ISSIA) and for Computational Linguistics Institute (CNR-ILC). His research interests include Human Robot Interaction (he is the father of CADDIAN, a language for human robot interaction in underwater environment), Natural Language Processing, data mining, information retrieval, sentiment analysis and networks (network theory, analysis and security).

Massimo Ianigro

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Massimo Ianigro received the M.S. degree (Laurea degree) in computer science in 1992 with a thesis on "Mobile robot navigation using ultrasonic sensors", from the University of Bari. After the degree, he has been awarded research contracts from National Research Council, SGS Thomson Microelectronics and Digital Equipment Corp. on various themes (optical flow reconstruction, robotics, high performance computing, networking). During 1995 he has worked at Manchester University in the Computer Graphics Unit. Since 1996, he is employed at the National Research Council, and he has worked in different units (Institute of Image and Signal Processing, Institute of Cristallography, Institute of Biomedical Technologies, Research Area of Bari) before joining ISSIA, in 2003. He has been teaching in several master and PhD courses and he is responsible for the networking infrastructure and telematics services used by a large number of CNR users and sites disseminated around the country. He is also a member of the GARR-CERT (Computer Emergency Response Team of the nation-wide network of academic institutions) and he is an expert appointed by italian law enforcement agencies in many computer forensic cases. Currently he is working with the Field and Interaction Robotics Group at ISSIA and his activity is focused on Unmanned Aerial Vehicles.

Roberto Colella

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Roberto Colella graduated in Physics in 2003 at the University of Bari, with a master thesis on the analytical-fuzzy modeling of the respiratory system for the control of artificial ventilator. From 2003 to 2007 he worked a consultant in the field of the monitoring of major contracts for the Public Administration. Then (2007 – 2008) he carried his research at the Institute of Intelligent Systems for Automation (ISSIA), dealing with the classification of genomic data for the study of rare diseases. From 2008 to 2011 he took part into Molecular Biodiversity Laboratory Project of IBM, where he developed software tools for the rapid assembly of bioinformatics workflow. During 2011 he has been working in the INFREP collaboration, dealing with the automated collection and the publication of the experimental data (VLF-LF) and developing an automated warning system for the Italian Civil Protection, based on the wavelet analysis of the collected data. In 2013 he get back to ISSIA as a research fellow, where he worked on the detection and the analysis of the cognitive status of on-board operators by mean of haptic feedback devices and on the experimental setup for image and spectra acquisition of agricultural products. In 2014 he joined the Field and Interaction Robotics group at ISSIA, where he deals with the simulation, development and testing of custom air and land robotic research platforms.