EXCELLABUST

EXCELLING LABUST IN MARINE ROBOTICS

EXPERT VISIT 1

19 - 20 January 2016

University of Girona

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1. VENUE

Gray Hall, University of Zagreb Faculty of Electrical Engineering (UNIZG-FER)
Address: Unska 3, Zagreb, Croatia

2. PREREQUISITES FROM PARTICIPANTS

It is required to have a computer with UBUNTU 14.04 LTS and ROS Jade already installed to not loose time preparing the system. To follow the course it will be also necessary to install the UWSim simulator and the COLA2 software architecture:

- To install UBUNTU 14.04
  http://releases.ubuntu.com/14.04/
- To install ROS
  http://wiki.ros.org/ROS/Installation
- To install UWSim:
  sudo apt-get install ros-jade-uwsim
  Once done, run UWSim for the first time. It will download some extra content.
  roscore & rosrun uwsim uwsim
- To install COLA2 architecture:
  Once your system is ready (UBUNTU and ROS installed), you have to create a catkin workspace (http://wiki.ros.org/ROS/Tutorials/InstallingandConfiguringROSEnvironment) to install the packages that form the COLA2 control architecture. Next, install de follow packages:
  cd ~/catkin_ws/src/
  git clone https://bitbucket.org/udg_cirs/auv_msgs.git
  git clone https://bitbucket.org/udg_cirs/cola2_core.git
  git clone https://bitbucket.org/udg_cirs/cola2_s2.git

- To check that everything has been correctly installed do:
  cd ~/catkin_ws/
  catkin_make

3. SCHEDULE

Day 1: 19 January 2016 (Tuesday)

08:30 – 09:00	**Meet and greet coffee**
09:00 – 10:00	**Presentation and introduction to ROS** by Narcis Palomeras
10:00 – 10:15	BREAK
10:15 – 11:00	**COLA2 architecture for AUV navigation, guidance and control** by Narcis Palomeras
11:00 – 11:15	BREAK
11:15 – 12:00	**COLA2 architecture for AUV navigation, guidance and control (continuation)** by Narcis Palomeras
12:00 – 13:30	LUNCH BREAK
13:30 – 14:15	**High-level architectures and path planning** by Marc Carreras
14:15 – 14:30	BREAK
14:30 – 15:15	**High-level architectures and path planning (continuation)** by Marc Carreras
15:15 – 15:30	BREAK
15:30 – 16:30	**Hands-on: AUV path planning** by Marc Carreras & Narcís Palomeras

Day 2: 20 January 2016 (Wednesday)

08:30 – 09:00	**Meet and greet coffee**
09:00 – 10:00	**High-level architectures and path planning (continuation)** by Marc Carreras
10:00 – 10:15	BREAK
10:15 – 12:00	**Hands-on: AUV path planning (continuation)** by Marc Carreras & Narcís Palomeras
12:00 – 14:00	LUNCH BREAK

4. EXPERT VISIT PLANNED OUTCOMES:

- Participants are introduced with the COLA2 architecture, for AUV programming, with practical experiences in a ROS environment.
- Participants are introduced with the basics of high-level control architectures and path-planning algorithms.
- Participants perform simulated experiments about AUV path planning

5. LECTURE DESCRIPTION:

1. **Presentation and introduction to ROS by Narcís Palomeras**
   In this lecture we will see how different robots are programmed, what is a control architecture, and why we need middlewares/frameworks/libraries... to develop modern control architectures. Then, we will introduce the Robot Operative System (ROS) and perform some basic exercises with it.

2. **COLA2 architecture for AUV navigation, guidance and control by Narcís Palomeras**
   We will present the ROS-based control architecture COLA2. This architecture is implemented in all AUVs developed at the University of Girona. The architecture is divided in several layers: Localization, Control, Guidance, Perception, Safety... The basic ones, which are the Localization and Control, will be detailed. Hands-on exercises will be done to explain the EKF-SLAM localization filter implemented in COLA2. More information about the architecture can be found at: https://bitbucket.org/udg_cirs/cola2_core/wiki/Home

3. **High-level architectures and path planning by Marc Carreras**
   This lecture will present the different kinds of control architectures that can be applied to autonomous robots, going from reactive to deliberative systems. Behaviour-based robotics will be introduced, as a fast and effective way of programming an autonomous vehicle. Then, the lecture will focus on path planning, as a more effective methodology for generating a path when a map of the environment is available. Different algorithms will be shown, such as Bug algorithms, Potential algorithms, Topological Maps, Cell Decomposition and Sampling algorithms. The lecture will conclude with the last group of methods, Sampling algorithms, going into details with the most used ones: RRT and PRM. Finally, the OMPL library, which is available from the ROS architecture, will be introduced, as it will be used in the hands-on proposed exercise.

4. **Hands-on: AUV path planning by Marc Carreras & Narcís Palomeras**
   In this session, we will propose a practical exercise in which the previous contents will be combined together. The students will a have a complete control architecture with a simulation environment, all using ROS, in which the AUV with the COLA2 architecture will move in a simulated environment with obstacles. The OMPL library will be used to generate paths, using several sampling algorithms, and the paths will be executed by the AUV. The students will have the opportunity to change the path-planning algorithm, to select the initial and goal position and to check how the different systems work.

6. DESCRIPTION OF THE PARTNER INSTITUTION:

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

Computer Vision and Robotics Research Institute,
University of Girona

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The University of Girona is a public institution devoted to excellence in teaching and research and to participating in the progress and development of society through the creation, transmission, diffusion and criticism of knowledge related to sciences, technology, humanities, social sciences and arts. The Computer Vision and Robotics Research Institute (VICOROB) at the University of Girona is devoted to the research related to the areas of computer vision, image processing and robotics. VICOROB is composed of 75 members (22 PhDs) and in the period 2007--2012 has participated in 21 European and Spanish Research Projects (4,5M€) and 23 Industry Contracts (1M€), has supervised 55 PhD/MSc theses and published 97 articles in journals, 47 book chapters and 180 conference attendances.

GIRONA **UNDERWATER VISION AND ROBOTICS**

Girona Underwater Vision and Robotics Lab

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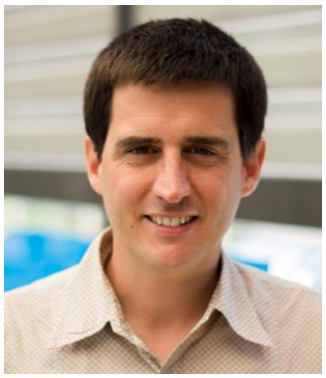
Girona Underwater Vision and Robotics research lab, as part of the Institute, has a strong experience in the design and development of hovering AUV prototypes with high--resolution image mapping capabilities. 5 AUV prototypes have been designed during the last 10 years, all of them having a different conceptual design. Being GIRONA 500 AUV and SPARUS II AUV the currently operative platforms. During the last years the team has worked on the development of advanced image processing techniques for the 2D and 3D mapping of the seafloor, as well as with the fusion of these techniques with navigation data coming from state of the art navigation sensors (DVL, gyros, USBL) together with global optimization techniques to face large--scale maps. Map based navigation and SLAM of underwater robots using both acoustics and/or video images is currently one of the main topics of research. VICOROB has also a long experience in intelligent control architectures and has contributed in mission control systems, behaviour--based architectures, robot learning and path planning for AUVs. Finally, the group has expertise in mechatronics and software integration. Recently, 4 Sparus II AUVs have been developed to be delivered to external research institutions, three of them participating in the EU--funded euRathlon underwater competition. UdG has consistently shown in the past that it can afford young and senior researchers the proper intellectual setting for training in the interdisciplinary field of cooperative autonomous robotics. After 20 years doing research, the team has become a benchmark in Europe for the design and construction of autonomous underwater vehicles, and the development of cutting edge software for the processing of visual and acoustic data. The team is also a member of TECNIO network of Excellence in technology transfer in Catalonia region. We are located in Scientific and Technological Park of the UdG.

7. BIOGRAPHIES OF LECTURERS



Assoc. Prof. Dr. Marc Carreras

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Marc Carreras (MSc 1998, PhD 2003) is Associate Professor in the Computer Engineering Department at UdG, and member of the VICOROB group working in the CIRS laboratory. He holds a B.S. degree in Industrial Engineering (1998) and PhD in Computer Engineering (2003, Best PhD award) from the University of Girona. Since 1999, he has participated in 14 research projects (6 European and 8 National), he is author of more than 80 publications, and he has directed 3 PhDs thesis (3 more under direction). His research activity is mainly focused on underwater robotics in research topics such as intelligent control architectures, robot learning, path planning, AUV design, modelling and identification.

Dr. Narcís Palomeras

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Narcís Palomeras (MSc 2004, PhD 2011) is a Postdoctoral Fellow in the Department of Computer Engineering of University of Girona (UdG), and a member of the Underwater Robotics Laboratory in the Computer Vision and Robotics Group (VICOROB). He holds a B.S. degree in Computer Science (2004) and a PhD in Computer Engineering (2011) from the University of Girona. He has participated in several research projects (both national and European) related with underwater robotics and has taken part in several European AUV competitions. His research activity is mainly focused on underwater robotics in research topics such as intelligent control architectures and mission control.