

STRONG MAR

Strengthening Maritime Technology
Research Center



STRONG
MAR

17 to 21 October 2016
Girona
Spain

- Underwater robotics
- Underwater vision
- Underwater mission planning

ORGANIZERS

Universitat
de Girona

VICOROB

GIRONA UNDERWATER
VISION AND ROBOTICS

FUNDING



The STRONGMAR project is funded by the European Commission under the H2020 EU Framework Programme for Research and Innovation (H2020-TWINN-2015, 692427).



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“Winter School on Underwater Vision and Robotics”

University of Girona, Spain
17 to 21 October 2016

WELCOME

Dear all participants, welcome to the first **STRONGMAR** winter school.

The aim of the **STRONGMAR** project is to create solid and productive links in the global field of marine science and technology between INESC TEC and established leading research European institutions, capable of enhancing the scientific and technological capacity of INESC TEC and linked institutions, helping raising its staff's research profile and its recognition as a European maritime research center of excellence.

The training strategy of the **STRONGMAR** project is based on sessions touching multidisciplinary aspects, followed by sessions focused on specific fields of expertise, allowing researchers to improve their knowledge and preparing them for the research and implementation challenges in the sea harsh environment. The training strategy targets not only theoretical training but also hands-on training, enabling direct application of the knowledge acquired and improve their understanding of the actual requirements of the stakeholders, allowing them to design solutions with higher economic potential.

Interchange and interaction among different fields of expertise is fundamental to address the ocean challenges, due to the multidisciplinary nature of the application area. Cross-fertilization among fields of expertise is also key to stimulate the design of better specific solutions.

This winter school (**Underwater Vision and Robotics**) will cover the following broad topics: Underwater Computer Vision and Robotics Research lines, Path planning for autonomous underwater vehicles, image processing for underwater mapping, hands on training on ROS AUV programming and hands on training on image processing.

The **STRONGMAR** team.

VENUE

The winter school will take place in the city of Girona, at the Science and Technology Park, located in the outskirts of the city.



How to arrive to Girona?

Girona city is only 65 km / 40 mi from the French border (100 km / 62 mi from Perpignan) and 100 km / 62 mi from Barcelona, the easiest way to arrive is fly either to:

Girona-Costa Brava Airport

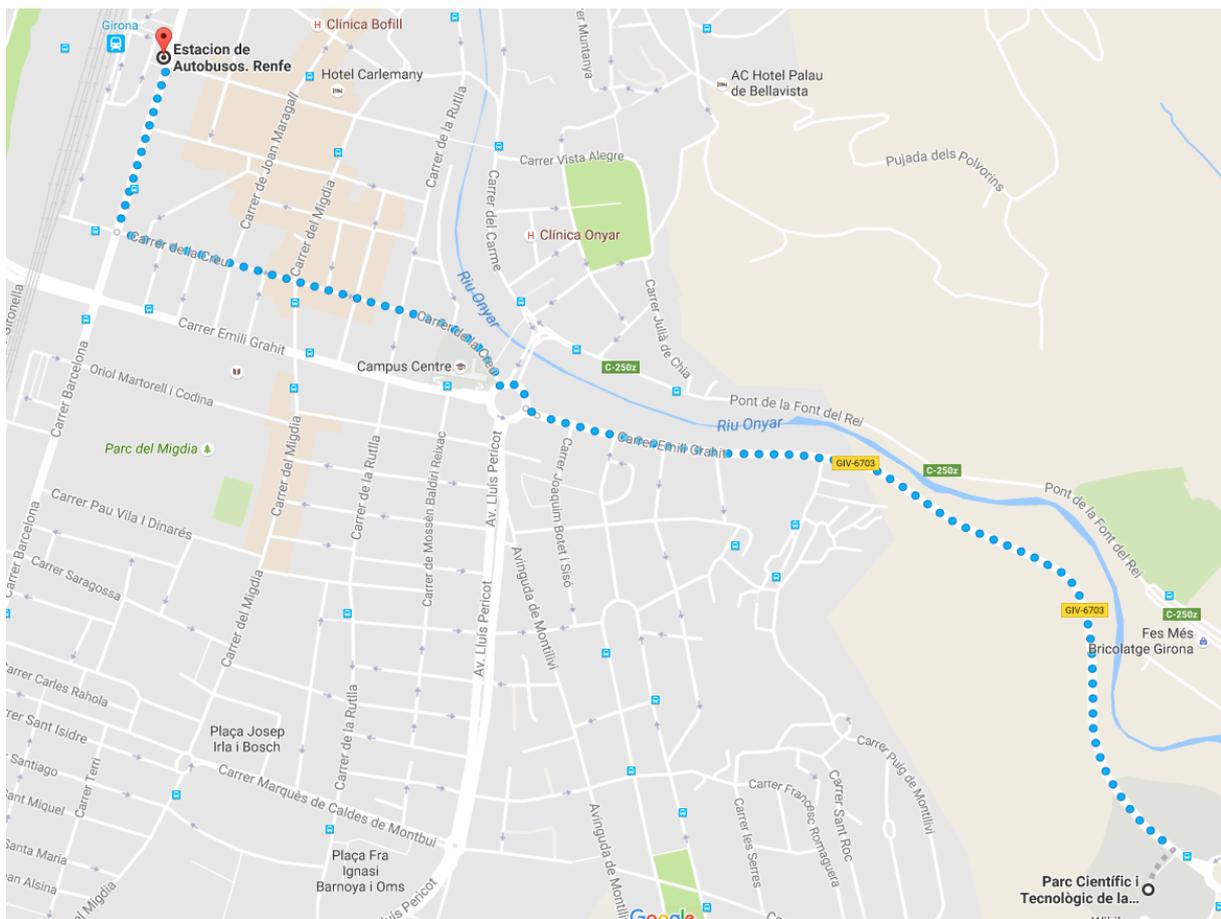
Girona-Costa Brava Airport has regular flights from cities in Europe and other parts of Spain. The airport is located about 12 km / 7 mi outside Girona, with good road connections to the city centre by car, coach or taxi. Road access into Girona city is by the N-II main road or the AP-7 motorway (taxi may cost you around 20 €). There is also a coach service into Girona bus station every 30'.

Barcelona-El Prat Airport

Barcelona-El Prat international airport receives regular European and intercontinental flights. Just 110 km / 68 mi away, there is direct access to Girona by motorway (taxi may cost you around 160 € and will take around 1h and 20 minutes to arrive) or train (you need to take the Barcelona area train to reach Barcelona-Sants train station and then pick the high speed train to Girona, the whole process will take you around 2 hours).

How to arrive to Science and Technology Park?

The Science and Technology Park is in the outskirts of the city. You can easily arrive walking (it will take you a 30-minute promenade around the river from the city centre), take a taxi (may take you 5 minutes and can cost you around 8 €) or take the bus L8 from the train station to Science and Technology Park stop (it leaves every 30 minutes and will cost you around 2 €/way).



Once there, you just need to follow the indications to Edifici Giroemprèn, then in the main floor, access B, downstairs (-1), you will find "Auditoris 2 and 3" where the training is going to take place.

Invited Dinner

On Wednesday evening there will be an invited dinner at **restaurant DRAPS**, in the city centre.
We will meet there at 20:30.

Carrer de la Cort Reial, 2, 17004 Girona

<http://en.restaurantdraps.com/>



SYLLABUS

PROGRAMME

	Monday	Tuesday	Wednesday	Thursday	Friday	
	17/10/2016	18/10/2016	19/10/2016	20/10/2016	21/10/2016	
9:00-10:30		Opening (J. Freixenet) CIRS - Robotics (P. Ridao)	UV training (R.Garcia / N. Gracias)	PP training (M. Carreras)	Departure from Girona	
10:30-11:00		Coffee break	Coffee break	Coffee break		
11:00-13:00		CIRS - Vision (R. Garcia)	UV training (R.Garcia / N. Gracias)	PP training (M. Carreras)		
13:00-14:30		LUNCH @Parc Café	LUNCH @Parc Café	LUNCH @Parc Café		
14:30-16:00		Invited Students presentations	UV training (R.Campos / N. Gracias)	COLA2 hands-on (N. Palomeras / J.D. Hernández)		
16:00-16:30		Coffee break	Coffee break	Coffee break		
16:30-18:00		Invited Students presentations	UV training (R.Campos / N. Gracias)	PP hands-on (N. Palomeras / J.D. Hernández)		
18:00-19:30		Arrival to Girona		PP hands-on (N. Palomeras / J.D. Hernández)		
20:30				Invited dinner @DRAPS Restaurant		

Lectures

Tuesday the 18th of October

CIRS Underwater Robotics by Pere Ridao

VICOROB-CIRS is a team devoted to the research and development of Autonomous Underwater Vehicles for accurate seafloor mapping and light intervention. With more than 20 years of experience, the team offers its engineering and field operations experience to companies and institutions in the context of research projects and contracts. In this lecture, we will present the research lines being carried out at the Underwater Robotics Research Centre of the Computer Vision and Robotics Institute of the University of Girona. The GIRONA 500 and SPARUS II AUV prototypes will be briefly described and the field results using those vehicles for science, archaeology and research applications will be reported.

CIRS Research on Underwater Computer Vision by Rafael Garcia

In this talk Dr. Rafael Garcia will present the research lines of the VICOROB-CIRS team in image processing for underwater applications. The principal challenges of computer vision in the underwater environment will be exposed. Next, results of the research projects developed during the last 10 years will be briefly outlined, including results on applications areas as divers as marine ecology, geology and deep water archaeology.

Wednesday the 19th of October

Introduction to Underwater Computer Vision by Rafael Garcia and Nuno Gracias

This lecture will present and review some of the basic concepts in underwater computer vision, with emphasis in image enhancement and mapping applications. The principal challenges of the underwater medium will be discussed, and a set of techniques will be described to overcome the most common forms of image degradation. The lecture will then focus on image motion analysis which is the central building block for creating optical maps. We will present the topics of Feature Extraction and Description, and of model-based Motion Estimation and Outlier Rejection. The lecture will conclude with algorithms for Image Topology Estimation and Global Alignment. Exemplary results will be presented on large area underwater mapping applications.

Underwater Vision hands-on by Ricard Campos and Nuno Gracias

This session will allow the participants to gain hands-on experience by building 2D optical maps, commonly referred to as photomosaics. The concepts of image motion estimation presented earlier will be put to practice. A processing pipeline will be assembled, starting from a set of individual underwater images and ending in a mosaic of the sea-floor.

This hands-on session requires the participants to have a computer with the following installation:

- Ubuntu OS
- Matlab

Thursday the 20th of October

Path planning (PP) training 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, giving examples on applications with underwater robots.

COLA2 hands-on 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.

Path Planning (PP) hands-on by Juan David Hernández

In this session, we will propose a practical exercise in which the previous contents will be combined together. The students will 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.

PREPARING YOUR LAPTOPS

Prerequisites from participants:

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

* To install UBUNTU 14.04:

<http://releases.ubuntu.com/14.04/>

* To install ROS - JADE version:

<http://wiki.ros.org/jade/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 & rosrn 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 the following 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 install dependencies and additional libraries:

```
$ sudo apt-get install ros-jade-rosbridge-server ros-jade-octomap-ros ros-jade-ompl
```

* To check that everything has been correctly installed do:

```
cd ~/catkin_ws/  
catkin_make
```

Further software will be installed on site. Any inquires in the installation process, please contact: narcis.palomer@udg.edu

HOSTING TEAM

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.

SPEAKER'S BIO



Pere Ridao

Dr. Pere Ridao who received the Ms.C. degree in computer science in 1993 from the Technical University of Catalonia, Barcelona, Spain, and the Ph.D. degree in computer engineering in 2001 from the University of Girona, Spain.

His research activity is mainly focused on underwater robotics in research topics such as intelligent control architectures, UUV modelling and identification, simulation, navigation and mapping, Mission Control and real-time systems. He joined the Institute of Informatics and Applications, University of Girona, in September 1995. Currently, he is an associate professor with the Department of Computer Engineering of the University of Girona. Currently he is involved in national projects (RAUVI or ARCHROV) and European projects (FP7 STREP TRIDENT, PANDORA, MORPH, EUROFLEETS 2, amongst others) about underwater robotics and some technology transference projects (INSPECSUB). Dr. Ridao is the chair of the IFAC's Technical Committee on Marine Systems and member of the editorial board of Springer's Intelligent Service Robotics journal.



Rafael Garcia

Dr. Rafael Garcia is the founder and director of the Underwater Vision Lab (UVL), which belongs to the Computer Vision and Robotics Group in the Department of Computer Architecture at the University of Girona (Spain).

His main research interests are underwater robotics and computer vision. Dr. Garcia is particularly interested in how to make unmanned underwater vehicles sense their environment to carry out autonomous surveys of the ocean floor.

From March 2010 to June 2015 he served as the director of the Computer Vision and Robotics Group of UdG. He serves as consultant to industry in the field of artificial vision and manufacturing, and he founded the spin-off company Coronis Computing SL, a company that commercializes Computer Vision and Machine Learning solutions.

Dr. Garcia is also interested in education, outreach and the public perception of science. To this end, he devotes part of his research group's efforts to education research. Since 2011 he is also the director of the Institute of Education Sciences (ICE) of the University of Girona. Moreover, his interests include educational innovation projects, especially those that try to increase student motivation and engagement.



Nuno Gracias

Dr. Nuno Gracias was awarded the Ph.D. degree in 2003 from the Technical University of Lisbon, Portugal. From 2004 to 2006 he was a post-doctorate fellow at the University of Miami. In 2006 he joined the Computer Vision and Robotics Group (ViCOROB) of the University of Girona. His research interests span the areas of underwater optical mapping, and navigation and guidance of autonomous underwater robots, and underwater image classification. Dr. Gracias has authored more than 60 articles in peer-review journals and scientific conferences, and co-supervised 2 PhD and 6 MSc theses. He is adjunct faculty at the department of Marine Geology and Geophysics of the University of Miami, and member of the editorial board of the Journal of Intelligent and Robotic Systems.



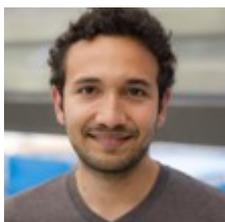
Marc Carreras

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.



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.



Juan David Hernández

He received his B.Sc. in electronic engineering from the Pontifical Xavierian University, Cali, Colombia in 2009 and his M.Sc. degree in robotics and automation from the Technical University of Madrid, Spain in 2012. He is currently a Ph.D. candidate in technology (robotics) at University of Girona, Spain. His research activity is focused on motion planning algorithms under motion and online computation constraints, especially applied to autonomous underwater vehicles (AUVs). He is also a software developer and maintainer of some modules of the COLA2, a control architecture that is currently used by the AUVs at the Girona Underwater Robotics Center (CIRS). He has been involved in different national projects (ARCHROV) and European projects

(FP7 MORPH, EUROFLEETS 2) about underwater robotics. Juan David Hernández is a member of IEEE and its robotics and automation society (RAS).



Ricard Campos

Dr. Ricard Campos received the Ms.C. degree in computer science (2009), the Master in "Automation, Computation and Systems" (2010) and the Ph.D. in technology (2014) from the University of Girona, Spain. His research interests are focused on 2D/3D mapping from optical data, especially focusing on underwater applications. Currently, he is a researcher at the Computer Vision and Robotics institute (VICOROB) of the University of Girona, and a member of the Underwater Vision and Robotics Research Center (CIRS). He has collaborated in many national projects (e.g., MUMAP, OMNIUS) as well as European projects (e.g., TRIDENT, MORPH).

LIST OF PARTICIPANTS

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