DEEPFIELD

Thematic Workshop on Autonomous Underwater Intervention

University of Girona, Spain

11 to 12 February 2020

Organizers:

Universitat de Girona

ViCOROB

GIRONA **UNDERWATER** **VISION AND ROBOTICS**

Funding:

WELCOME

Dear all participants, welcome to the first DEEPFIELD winter school.

The aim of the DEEPFIELD project is to create a solid knowledge and productive links in the topic of deep-learning in field robotics 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 and reference in field robotics.

The training strategy of the DEEPFIELD 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 thematic workshop (Autonomous Underwater Intervention) will cover the following broad topics:

Control of vehicle manipulator systems, to enable autonomous underwater intervention, including redundancy resolution through a task hierarchy as well as compliant control concepts, navigation strategies and algorithms to enable precise positioning and velocity control, and finally, utilising recently developed simulation tools for testing complex underwater intervention scenarios.

The DEEPFIELD 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 190 € 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).
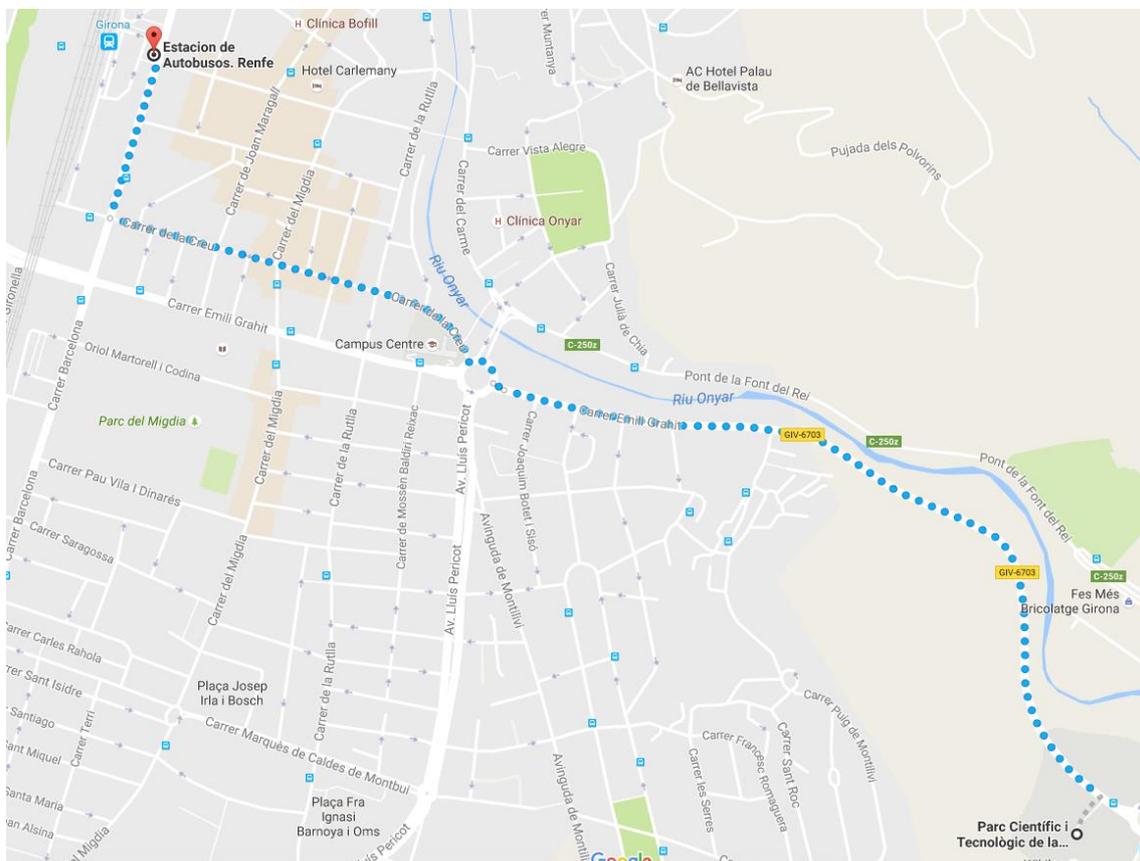
Once there, you just need to follow the indications to Edifici Giroemprèn, then in the main floor, access B, downstairs (-1), you will find "Auditoris 2 and 3" where the training is going to take place.

Dinner

On Tuesday evening there will be an invited dinner at **restaurant DRAPS**, in the city centre. We will meet there at 21:00.

Carrer de la Cort Reial, 2, 17004 Girona

http://en.restaurantdraps.com/

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WINTER SCHOOL SYLLABUS

PROGRAMME

	Monday 2/10/2020	Tuesday 2/11/2020	Wednesday 2/12/2020
9:00-9:15	Arrival to Girona	Welcome and introduction (P. Ridao)	COLA2 software architecture (G. Vallicrosa)
9:15-10:30		State of the art in I-AUV research (P. Cieslak)	
10:30-11:00		Coffee break	
11:00-11:30		AUV modelling (P. Ridao)	Coffee break
11:30-12:00			Stonefish simulator (P. Cieslak)
12:00-13:30		AUV navigation (G. Vallicrosa)	
13:30-15:00		LUNCH	LUNCH
15:00-17:00		I-AUV theory (P. Ridao)	Simulated experiments in autonomous manipulation (I-AUV control) (P. Cieslak)
17:00-19:30		Free time	Back to Porto
19:30-20:45		Social activity (Girona touristic walk)	
21:00		DINNER Draps Restaurant	

PROGRAMME

Tuesday the 11th of February

Welcome and introduction 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.

State of the art in I-AUV research by Patryk Cieslak

During this lecture a survey about the autonomous intervention using the underwater robotic platforms will be presented. This will include some motivation of the research in this field, history of the developments, information about recent projects and, specifically, projects completed and running in the CIRS laboratory as well as new ideas appearing in the field.

AUV modelling by Pere Ridao

This lecture presents the hydrodynamics equations of motion of an underwater vehicle. The equations are useful either for simulation or model based control. First, the involved reference frames will be presented to continue with the robot kinematics and dynamics. The lecture ends introducing an identification method that can be used to estimate the physical parameters defining the model.

AUV navigation by Guillem Vallicrosa

Navigation is a crucial part of the I-AUV system. It is necessary to be able to achieve desired velocity, orientation and position of the robot in the world frame. Different navigation algorithms will be presented, based on the implementation of the Extended Kalman Filter (EKF). This will include sensor based (IMU, GPS, DVL...) as well as map based navigation and their practical realisation in our robots.

I-AUV theory by Pere Ridao

This final theoretical lecture will present topics revolving around the control of mobile manipulator systems, specifically underwater mobile manipulators. It will introduce the possible control algorithms, focusing specifically on the Task Priority algorithm in its modern form as well as compliant control concepts. This knowledge will be later exploited in the simulation as well as water tank experiments.

Wednesday the 12th of February

COLA2 software architecture by Guillem Vallicrosa

COLA2 is the common software architecture for both Girona 500 AUV and Sparus II AUV that offers a similar interface to both robots. This session will introduce COLA2 and its different modules, focusing on navigation and control which are the most relevant modules used for underwater intervention.

Stonefish simulator by Patryk Cieslak

This presentation and a hands-on demo will showcase the simulation tools recently developed in our laboratory, to support researchers working in autonomous intervention. The architecture and functionality of the tools will be presented first, followed by examples of usage and customisation for specific needs.

Simulated experiments in autonomous manipulation by Patryk Cieslak

This hands-on demo will put in practice the theoretical knowledge and the presented simulation tools, to enable the students to successfully run a set of autonomous robotic intervention scenarios and understand how different parts of the control algorithms are affecting the behaviour of the system. In this demo the students will be introduced to multiple packages developed in our lab, focus around perception and control algorithms.

PREPARING YOUR LAPTOPS

Prerequisites from participants:

It is required to have a computer with UBUNTU 18.04 LTS and ROS Melodic already installed, to not lose time preparing the system. It is also required that the computer must support OpenGL 3.3 as minimum and preferably have a discrete GPU apart from the integrated one. It is important to ensure that the computer is using the discrete GPU and that the drivers are installed correctly and updated. To follow the course it will be also necessary to install the Stonefish simulator and the COLA2 software architecture. A gamepad compatible with Logitech F310 is an optional but useful add-on.

* To install UBUNTU 18.04:

  http://releases.ubuntu.com/18.04/

* To install ROS - MELODIC version:

  http://wiki.ros.org/melodic/Installation

* To install COLA2 architecture:

  Follow the instructions under the following link

* To install STONEFISH simulator:

  1. Install the Stonefish C++ library from http://github.com/patrykcielsak/stonefish
  2. Install the stonefish_ros package from http://github.com/patrykcieslak/stonefish_ros
  3. Install the stonefish_cirs package form http://github.com/patrykcieslak/stonefish_cirs

     All repositories are open-source and come with installation instructions in the README

* Be sure to compile the catkin workspace with all packages, to check for errors

CIRS Research Lab

Girona Underwater Vision and Robotics research lab, as part of the Institute, has a strong experience in the design and development of hovering (I-)AUV 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 and commercialised 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. The second main research line of the lab is the autonomous underwater intervention, based on floating-base manipulation from the GIRONA500 I-AUV platform. The research projects in this field covered valve turning on underwater panels and complex pipe structures, non-destructive testing utilising compliant control concepts as well as motion planning for navigation and manipulation.

VICOROB has 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.

DEEPFIELD

SPEAKERS AND TRAINERS

Pere Ridao

Pere Ridao received the Ph.D. degree in computer engineering in 2001 from the University of Girona, Spain. Since 1997, he has participated in 19 research projects (10 European and 9 National), he is author of more than 100 publications, and he has directed 9 PhDs thesis (4 more under direction) and 13 MS Thesis. His research activity focuses on designing and developing Autonomous Underwater Vehicles for 3D Mapping and Intervention. He is the director of the Computer Vision and Robotics Research Institute (VICOROB) and the head of the Underwater Robotics Research Center (CIRS) and an Associate professor with the Department of Computer Engineering of the University of Girona and a co-founder of Iqua Robotics SL, an University of Girona spin-off company.

Patryk Cieślak

Dr. Patryk Cieślak received his PhD in 2016 from the Department of Robotics and Mechatronics, AGH University of Science and Technology in Kraków, Poland. He was involved in several projects concentrating around control system design in mobile robotics and manipulator systems. He is also a co-author of a commercial rehabilitation robot called Prodrobot, being a stationary lower limbs exoskeleton, used in the relearning and improvement of natural gait patterns of children. Recently, his research interests focus around autonomous underwater mobile manipulation. For the last two years he worked as a Marie Curie postdoc in the Underwater Vision and Robotics Lab (CIRS) by the University of Girona, Spain. During the project he developed control strategies for compliant autonomous underwater mobile manipulation, utilising a wrist mounted force-torque sensor. He was also involved in works on underwater obstacle avoidance and motion planning. Patryk Cieślak is also the author of a modern open-source simulation software, directed towards underwater robotics community, called Stonefish. Recently, he is continuing his research in CIRS, working on cooperative autonomous underwater floating-base manipulation.

Guillem Vallicrosa

Dr. Guillem Vallicrosa who received a BSc in Industrial Engineering in 2007 from Universitat de Girona, the MSc in Erasmus Mundus Master in Computer Vision and Robotics (VIBOT) in 2013 from Université de Bourgogne, Universitat de Girona and Heriot-Watt University, and the PhD in Technology in 2018 from Universitat de Girona. His research activity is mainly focused on underwater robotics in research topics such as navigation and mapping, docking, acoustic communications and localization, simulation and real-time systems. He joined the Underwater Robotics Research Center, Universitat de Girona, in June 2012 where he is now a postdoc researcher. He is currently involved in national projects (TRITON, MERBOTS, TWINBOT) and European projects (MORPH, EUROFLEETS2, SUNRISE, EUMR amongst others) about underwater robotics.

LIST OF PARTICIPANTS

SPEAKERS AND TRAINERS

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