EXCELLABUST

EXCELLING LABUST IN MARINE ROBOTICS

EXPERT VISIT 4

11 – 12 April 2017

University of Girona

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 691980.

EXCELLABUST

1. VENUE

TCR, 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 16.04. For a detailed description refer to the attached documentation file ("Excellabust_Zagreb_mosaicing_tutorial.pdf").

3. SCHEDULE

Day 1: 11 April 2017 (Tuesday)

09:00 – 09:30	**Meet and greet coffee**
09:30 – 10:00	**Presentation and introduction to the seminar** by Ricard Campos
10:00 – 10:15	BREAK
10:15 – 11:00	**Overview and setup of the software for the hands-on** by Ricard Campos
11:00 – 11:15	BREAK
11:15 – 12:00	**Introduction to Underwater Imaging and its challenges** by Rafael Garcia
12:00 – 13:30	LUNCH BREAK
13:30 – 14:15	**Feature Detectors and Descriptors** by Rafael Garcia
14:15 – 14:30	BREAK
14:30 – 15:15	**Feature Detectors and Descriptors (continuation)** by Rafael Garcia
15:15 – 15:30	BREAK
15:30 – 17:00	**Image Registration and Homography estimation** by Rafael Garcia

Day 2: 12 April 2017 (Wednesday)

08:30 – 09:00	**Meet and greet coffee**
09:00 – 10:00	**Global alignment** by Ricard Campos
10:00 – 10:15	BREAK
10:15 – 12:15	**Hands-on: 2D Mapping** by Ricard Campos
12:15 – 14:00	LUNCH BREAK

4. EXPERT VISIT PLANNED OUTCOMES:

- Participants will be introduced to the challenges of underwater vision.
- An algorithmic approach to 2D mapping will be analysed and understood in detail.
- Participants will also be exposed to 2D mapping with a hands-on experience in a complete pipe-line to generate a photomosaic from underwater imagery.

5. LECTURE DESCRIPTION:

1. **Presentation and introduction to the seminar by Ricard Campos**
   In this welcome presentation we will introduce the outline of the seminar, motivating its importance in the context of seafloor exploration.

2. **Overview and setup of the software for the hands-on by Ricard Campos**
   During this class, we will overview the hands-on tutorial where we will put in practice the topics covered in the lectures to be presented during the first day. Since the tutorial requires the installation of some pieces of software, in this lecture we will perform all the installation steps required, so that we have time to solve the possible issues that may appear. To ensure the proper development of the tutorial, a computer with Ubuntu 16.04 is required.

3. **Introduction to Underwater Imaging and its challenges by Rafael Garcia**
   This lecture will show how imagery can be very useful to characterize the seafloor, and to provide a permanent visual record of its conditions. However, light suffers from a rapid and nonlinear attenuation underwater that affects the acquired images, which forces underwater robots to navigate close to the seafloor, depending on the visibility conditions, thus increasing the risk of the survey mission. The lecture will illustrate the image forming process underwater, and will introduce the concept of dehazing to minimise the effects of light scattering and attenuation.

4. **Feature Detectors and Descriptors by Rafael Garcia**
   Optical imaging surveys of the seafloor often yield large numbers of images (several tens of thousands, especially in deep-sea cruises) that are frequently underutilized largely because of the difficulties inherent in processing and visualizing large data sets. Building a photomosaic is a coherent way to exploit these data. In this session, we will study in detail the fundamental step of detecting correspondences in a pair of images, which will later allow the alignment of the images in a common reference frame, thus building a mosaic of images.

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6. **Image Registration and Homography estimation by Rafael Garcia**
   This lecture will deal with the problem of aligning images from point correspondences that may include outliers. We will see the hierarchy of planar transformations (similarity, Euclidean, affine and projective), and how the selection of a motion model affects the construction of a photomosaic. Finally, we will deal with outliers by studying a well-established robust estimator: the RANSAC algorithm.

7. **Global alignment by Ricard Campos**
   In this lecture we will see how once all the images have been parwise aligned, cumulative error provokes inconsistencies in the map. When the robot revisits a previously surveyed area, it is essential to detect and match the non-time-consecutive images to close a loop and, thus, improve trajectory estimation. We will see how to obtain a coherent two-dimensional mosaic and

simultaneously get the best possible trajectory estimation by exploring the contribution of the image pairs matching to the whole system.

8. **Hands-on: 2D Mapping by Ricard Campos**
   This hands-on tutorial will cover the steps required to construct a 2D mosaic from a set of images. We will apply the main steps in the pipeline, mainly: feature detection/description, pair-wise robust feature matching and motion estimation and global alignment. The use of navigation readings to aid the mosaic construction and produce a georeferenced map will also be explored.

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

Address: Edifici PIV, Campus Montilivi
Universitat de Girona
17071 Girona
Spain
Website: http://vicorob.udg.edu

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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17003 Girona
Spain
Website: http://cirs.udg.edu
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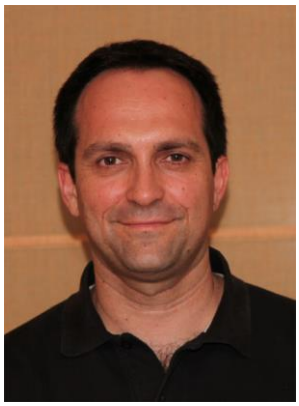
http://eia.udg.es/~marcc
marc.carreras@udg.edu

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.

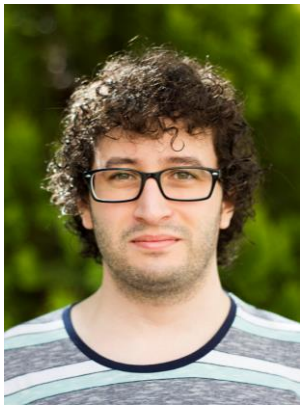
7. BIOGRAPHIES OF LECTURERS



Prof. Rafael Garcia

Website: http://eia.udg.edu/~rafa
Email: rafael.garcia@udg.edu

RAFAEL GARCIA graduated in computer engineering in June 1994 at the Autonoma University of Barcelona (UAB), received the DEA (MSc) in Computer Science in July 1996 and the Ph.D. degree in computer engineering in 2001, both at the University of Girona (UdG), Spain. His research activity mainly focuses on robotics in topics such as robot navigation and mapping, sensor fusion, 3D reconstruction, semantic representation of video imagery and large-scale mosaicing. Dr. Garcia was the director of the Computer Vision and Robotics Group (VICOROB) of the University of Girona from March 2009 to June 2015. Currently, he is the director of the Underwater Vision Lab, which belongs to VICOROB. Dr. Garcia has been visiting researcher at the Universität der Bundeswehr (Germany), University College Cork (Ireland), IRISA-INRIA (France), and the University of Miami (USA). He is involved in several national and transnational projects in the field of robotics and computer vision and has participated in the creation of two spin-off companies.



Dr. Ricard Campos

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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).