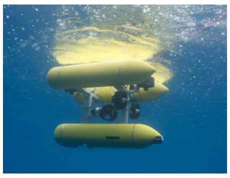
1ST FIELD TRAINING WORKSHOP IN UNDERWATER ROBOTICS INTERVENTION

ROSES (SPAIN), 17-21ST OCTOBER 2011

During the 3rd week of October 2011, the TRIDENT Field Intervention Workshop was held in Roses (Girona-Spain). With the participation of all the project partners, the event aimed at training young researchers in the different technologies involved in autonomous underwater intervention. Two days were devoted to lectures, and three days to field experiments in a harbour environment. This newsletter reports the main experimental achievements.

Hardware — **October 2011**

GIRONA500
Reconfigurable AUV designed and developped at Udg.
Page 2



Nessie AUV
Torpedo Shaped AUV designed & developped at HWU.
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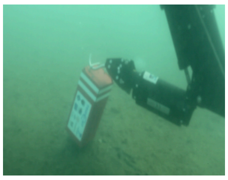
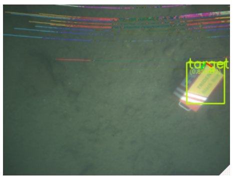
4 DOF arm 5E
Light weight 4 DOF arm 5E adapted and programmed by UJI
Page 2



Stereo pair
Stereo Pair adapted and programmed for target detection by UIB.
Page 2



7 DOF arm
Designed & developped by Graaltech. programmed by UNIGE.
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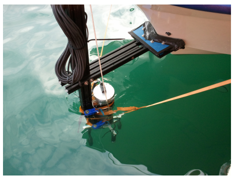
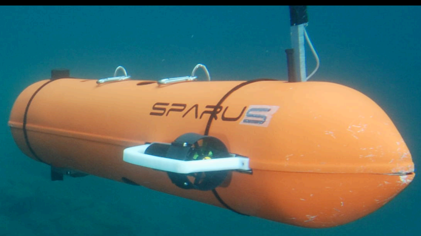
Custom USBL
Designed & developped by IST.
Página 3



Lectures



Each WP lectured the audience about the main scientific & technological aspects of their work

Who is who? **October 2011**

The TRIDENT FALL-SCHOOL on I-AUVs was addressed to meet the specialists who are working close to the topic of autonomous underwater intervention. Participants presented their results by means of lectures and demos at sea in a harbour at Roses - Girona - Spain.

Invited Lecture

Dr. Joan Solà (Ictineus Submarins S.L.) was invited to lecture about the design and current status of development of the Homan Operated Vehicle (HOV) ICTINEU.

ICTINEU 3 is a manned Submersible Designed and Developped by the Catalan company ICTINEU Submarins S.L

L1: Vehicles Cognitive Control Architecture

Dr. Carlos Insaurralde (HWU) explained the multiple vehicles cognitive architecture under development in TRIDENT project focussing in the high level point of view.

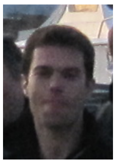
Joel Cartwrigth (HWU) presented the Service Oriented Architecture (SOA) being implemented in ROS. The SOA will be responsible for the gluing of all the software components implemented by the partners.

L2: Navigation & Mapping

Dr. David Ribas (UdG) taught an introduction to classical navigation methods as well as to the principles of sonar based underwater SLAM (Simultaneous Localization and Mapping).

Dr. Nuno Gracias (UdG) introduced the Image mosaicing technology to the audience. Several examples of 2D and 3D mosaicing were reported.

L3: Single & Multiple Vehicles Control



Dr. Pedro Batista (IST) presented an overview of the cooperative navigation algorithms developpend in the context of the project. HE also introduced the homing and docking controllers.

Marco Morgado (IST) presented the status of development of the custom integrated INS-USBL system which will be integrated in an inverted USBL configuration.

L4: Visual & Acoustic Image Processing

Stephan Wirth (UIB) presented the object recognition algorithms used for balck box detection and tracking.

Dr. Volker Nannen (UIB) presented an algorithm for real time 2D visual odometr using a feature based method which estimates the homographies between consecutive grabbed images.

L5: Free-Floating Manipulation

Professor Pino Cassalino (UNIGE) presented the methods and algorithms under development for the coordinated AUV arm motion and control.

Dr. Sandro Torelli (UNIGE) demonstrated the motion control of the TRIDENT arm developped by the GRAALTECH company.

L6: Hand-Arm Mechatronics Systems & Control

Dr. Gianluca Palli (UNIBO) described the mechatronics designed and developped in TRIDENT. The modular electrical driven robotic arm and the three fingered hand were presented.

L7: Multisensory Based Manipulation Archietecutre

Dr. Mario Prats (UJI) presented the multipurpose underwating grasping methodology. He reported the mechatronics integration efforts and reported field results involging UJI/UdG/UIB.

Organization

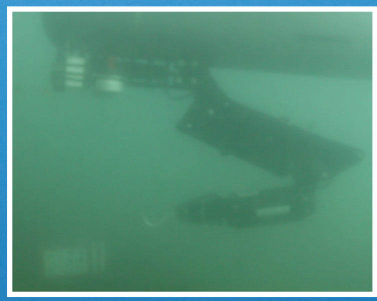
Joseta Roca is the project manager of the UdG team. She was the responsible of the administrative organisation.

Dr. Xevi Cufi (UdG) was the chair or the national organising comitte of the 1st Field Training School in Autonomous Underwater Robotics Intervention.

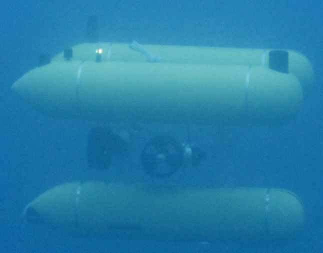
Object Search and Recovery from simulation to field Harbour Tests

HIL Simulation (January 2011)

Water tank demonstration (May 2011)



Harbour demonstration (Oct. 2011)



Field Testing

Object Search and Recovery demonstrated at Roses Harbour

GIRONA500 I-AUV

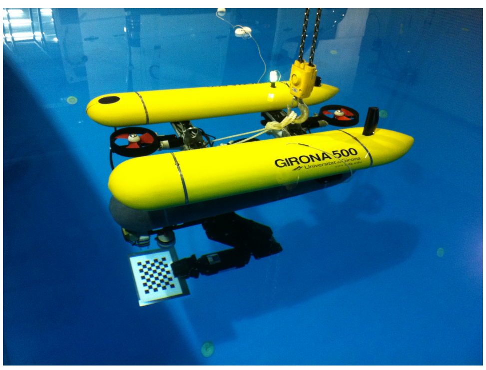
GIRONA500 UdG vehicle has been equipped with the light weigh arm 5E from UJI and an stereo pair from UIB completing the mechatronics integration of the I-AUV (Intervention AUV).

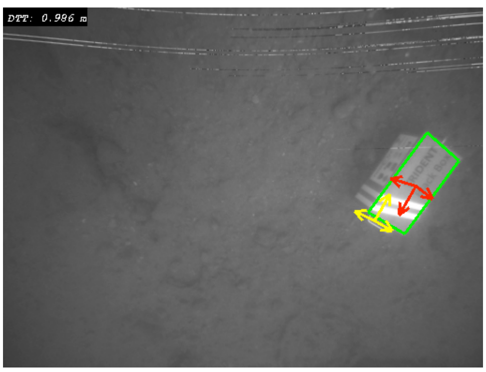
In order to simplify the development and testing the complete I-AUV system was splitted in three parts: 1) the AUV, 2) the Arm and 3) the computer vision system. During the week before the workshop, the tree systems developped at each institution were put together at CIRS lab.

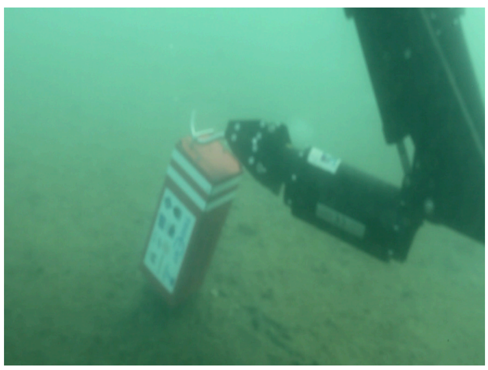
Each system includes its own pressure vessel with its own computer system to make more symple the systems integration at this first stage. Hence it was necessary to install all the system as well as to include additional buoyancy foam. Once integrated, all the systems were checked and the cameras calibrated at the water tank.

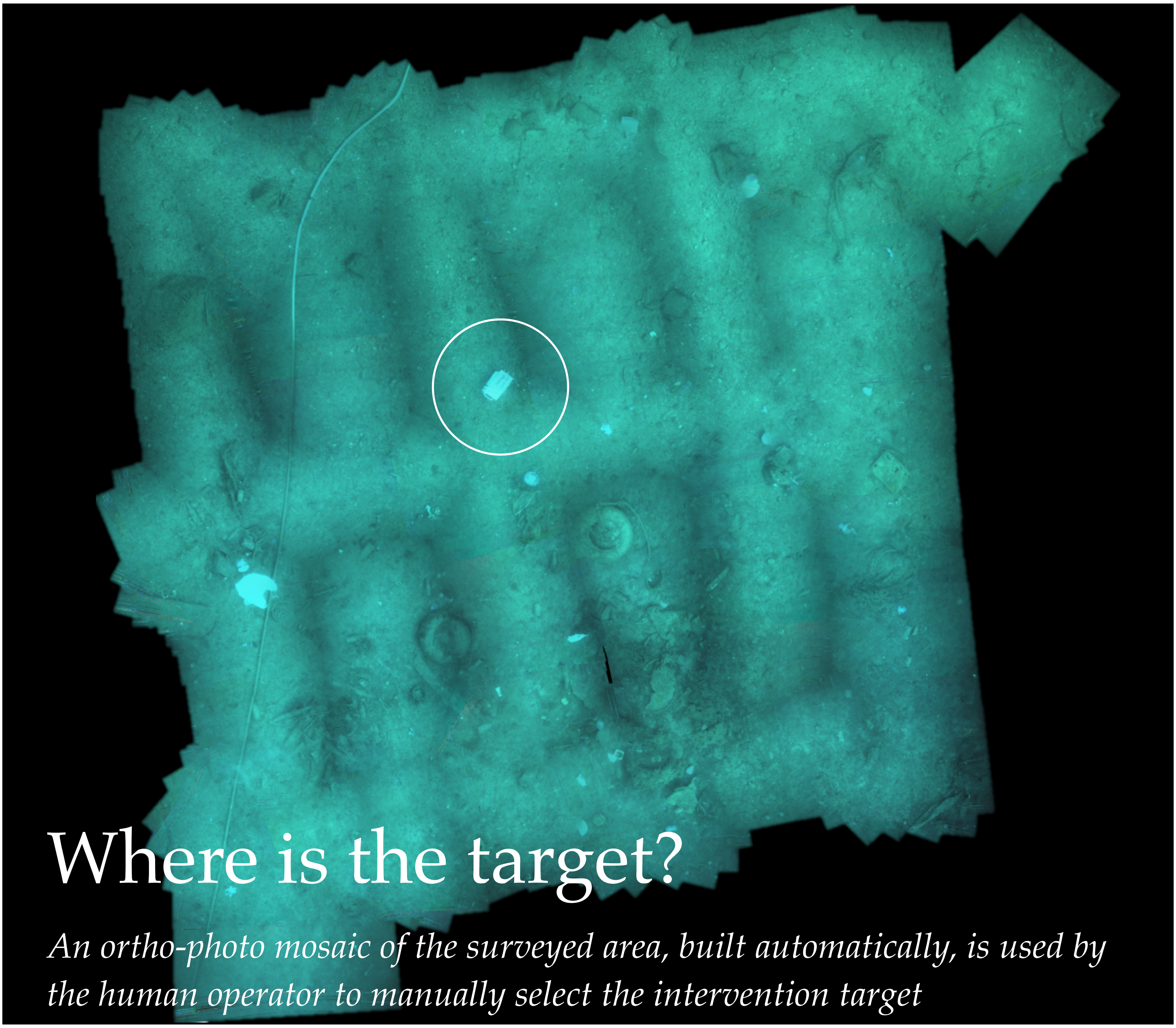
At the Rosas Harbour, the robot was deployed using the crane mounted on FALCO ship (Roses Diving Centre). Field experiments started next. The black box mockup was through and the vehicle was programmed to conduct a visual survey. With the imagery gathered a seafloor orthophotomosaic was setup and the balck box possition was identified.

Then, the experiments for object recovery started. First it was checked that the object detection and tracking was working properly. Next, object tracking was used for driving the station keeping to a pose suitable for the autonomous grasping. Because it is assumed that in real conditions te I-AUV will not land on the target object but in its neighbourhood, an obsject search strategy was programmed. In this strategy, when the vehicle dives to the region of Interest, it conducts a search pattern while looking for the target in theimages gathered byt the camera. When the target is found, the vehicle switchs to target station keeping and launches de manipulation. The proceure followed is the following: 1) the image is processed and the target identified and tracked, 2) the grasping module decides the vest position for the AUV, 3) the AUV adopts the requested pose. This procedure is performed continously while the grapsing takes places.









Where is the target?

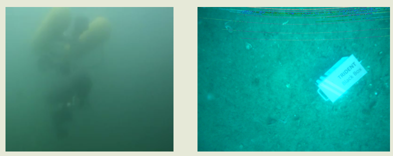
An ortho-photo mosaic of the surveyed area, built automatically, is used by the human operator to manually select the intervention target

In order to locate the object of interest we are looking for (in this case, the simulated black box), the robot is required to perform a survey of an underwater area. Apart from other sensors, the robot gathers imaging data. Using computer vision techniques, the surveyed area can be mapped in a common plane, which allows us to get an optical map of the seabed.

Having the set of images collected by the robot, the process starts by finding a set of points called features on each of them, which represent points that are surrounded by distinctive texture that should make them easily recognizable in other images. Next, the texture surrounding those points in the image is characterized using a feature descriptor. With the set of features/descriptors for each image, we search for correspondences between consecutive image pairs. To do so, we compare the descriptors of the features in each image. However, simply using the similarity between descriptors could lead to obtaining outliers, which are wrong associations between two image points that look similar but do not correspond to the same point in the sea floor. In order to avoid this, a robust model estimator is used (RANSAC), where the correspondences are considered valid if they follow the same motion model. A basic assumption behind this estimator is that we are looking at a rigid scene. With this step, we also recover the motion model in the form of a homography (3x3 matrix).

Once we have the homographies between consecutive images, we can obtain a first approximation of the trajectory followed by the camera by concatenating them. As it happens with all localization methods that rely on many sequential motion estimates to infer the robot position, errors are rapidly accumulated, and the map gets distorted. However, we can use this first approximation to find new image pairs that could correspond to the same area, and thus, could be matched together. Candidate matches between non-consecutive images are found, and now this information is merged together. In order to do it, we perform a non-linear optimization that takes into account the reprojection error (differences between the location of the detected feature, and the estimated position after projecting using the homographies). Moreover, this optimization procedure allows including navigation data provided by other sensors of the robot. Since this navigation data is georeferenced (UTM coordinates), the resulting mosaic will also be georeferenced.

Having a georeferenced mosaic, we will be able to inspect the mosaic offline, locate the object of interest we are looking for, and program the robot to go back to this position to perform the intervention task.



Black box recovery is a manipulation benchmark used in TRIDENT

Three Vehicles operated at sea

Nessie AUV was used to test LBL Navigation & Homing Control
SPARUS AUV performed navigation & guidance tests

THE TRIDENT ARM-HAND SYSTEM

The TRIDENT arm is now ready. Its functioning was demonstrated during the workshop. It is a

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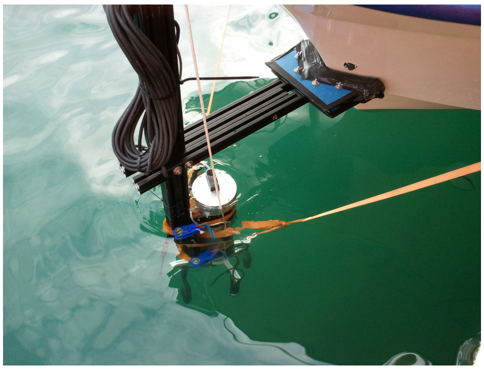
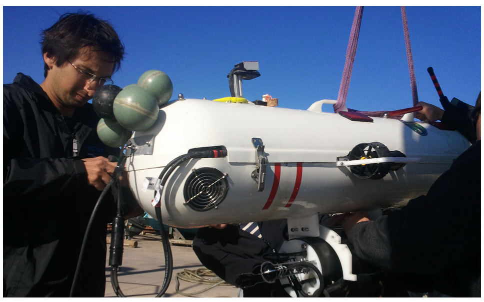
Custom USBL



According to the roadmap for the TRIDENT project, the IST team proposed the achievement of two main goals during the first intervention week: the experimental validation of the ultra-short baseline system (USBL) and the integration and experimental test of control laws in ROS.

The fist goal revealed that the spread spectrum acoustic signals that were selected do not interfere with the remaining acoustic-based systems operating in the vicinity, thus allowing for its integration in the near future onboard the G-500 I-AUV. It was also possible to successfully operate the USBL from the surface, providing the position estimate of a transponder installed on-board a support vessel.

The homing control law that was previously developed was successfully integrated in ROS jointly with the Heriot-Watt University, in a reduced period of time. Thursday morning, it was possible to validate the software integration and the control law performance at sea with minimal effort, thus paving the way to joint efforts to pursue the next steps in TRIDENT roadmap.



Nessie AUV

Heriot-Watt University, United Kingdom, participated in the experiments providing their Nessie VI underwater vehicle for algorithms testing and integration into their intelligent control architecture. The vehicle is a five degrees of freedom torpedo-shaped vehicle equipped with 2 stereo pairs and a forward looking sonar. It also has an acoustic modem enabling vehicle to vehicle communications and Long Baseline positioning.

During the experiments, video and acoustic imagery were gathered for further analysis and geo-referenced. In a second step, the ability of the vehicles to be located using a Long Baseline System was tested. Finally, we integrated video based motion estimation algorithms and control strategies for homing developed at the University of the Balearic Islands, Spain, and the Instituto Superior Technico of Lisbon, Portugal. Both were tested successfully.

Universitat Jaume I de Castellón (Spain)
Dr. Pedro J. Sanz
Multisensory Based Manipulation Architecture

Universitat de Girona (Spain)
Dr. Pere Ridao
Navigation and Mapping

Universitat de les Illes Balears (Spain)
Dr. Gabriel Oliver
Visual/Acoustic Image Processing

Università di Bologna (Italy)
Dr. Claudio Melchiorri
Mechatronics System and Control

Università di Genova (Italy)
Prof. Giuseppe Casalino
Floating Manipulation

Instituto Superior Técnico (Portugal)
Dr. Carlos Silvestre
Single and Multiple Vehicles Control

Heriot Watt University (United Kingdom)
Dr. Yvan Petillot
Vehicles Intelligent Control Architecture

Graal Tech (Italy)
MSc. Andrea Caffaz.
Electromechanical design of the arm

1ST FIELD TRAINING WORKSHOP IN UNDERWATER ROBOTICS INTERVENTION

TRIDENT

SEVENTH FRAMEWORK PROGRAMME