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Joint **E**uropean **R**esearch **I**nfrastructure network for **C**oastal **O**bservatory – **N**ovel **E**uropean e**X**pertise for coastal observa**T**ories

TNA PROJECT REPORT

1. Project Information

Proposal reference number	JN-CALL 2_6
Project Acronym (ID)	ADVANCE
Title of the project	Automatic Data and Video Acquisition for uNderwater monitoring across Coastal Environments
Host Research Infrastructure	Cabled Observatory OBSEA (UPC) ; Cabled Observatory CPO (SBI)
Starting date - End date	2018/04/03 – 2019/03/29
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User group members	Simone Marini, CNR-ISMAR, Italy Emanuela Fanelli, Università Politecnica delle Marche, Italy Jacopo Aguzzi, Consejo Superior de Investigacio Científicas, Spain Ernesto Azzurro, Istituto superiore per la ricerca ambientale, Italy

2. Project objectives

The short-term objective of the ADVANCE project is the test of the imaging device GUARD1, described in the European Patent EP2863257A1, as a stand-alone and autonomous sensor capable of quantifying biological activities at individual, population, and community levels. The GUARD1 consists of a low-power system conceived for installation on both fixed and mobile platforms for acquiring images of objects or organisms from 1 mm to 100 cm in size. On-board the device, the image content can be autonomously analyzed, recognized and classified. Even if the GUARD1 is capable to transmit the information extracted from the acquired images outside the device, in this project, such data will be stored in order to be accessed for further analysis after the recovery.

The medium-term objective of the ADVANCE project is the assessment of the GUARD1 imaging device by comparing the information automatically produced by the system with the visual inspection of the images acquired by the cameras that the two observatories provide. In particular, the images will be acquired continuously during the day and night (by using the GUARD1 lighting system) for a period of at least two months, in order to estimate the image quality with a different diffusion of light and with different conditions of water turbidity.

3. Main achievements and difficulties encountered

SmartBay deployment: During the deployment, about 100 ml of water entered the housing and definitively damaged the battery pack. As a consequence, the battery pack got completely discharged in only 10 days of acquisition. Due to the housing damage, an unplanned shipment of the device was performed from Galway to CNR-ISMAR on 9th October 2018. After further analysis a small scratch was found in the housing near the caseback, and the rechargeable battery pack needed to be replaced. During this deployment 635 images were acquired by the GUARD1 and contextually images and short video clip were also acquired, in the same field of view, with CPO videocamera.

OBSEA deployment: due to the GUARD1 damage, the new imaging device called DeepEye was sent to Vilanova i la Geltru' for performing the planned experiment. Since the DeepEye was released on July 2018, the experiment at the OBSEA was considered as a test for assessing its hardware reliability and its capability of acquiring images useful for ecological applications. During the OBSEA experiment, two deployment were performed for testing different image acquisition and elaboration parameter settings. The two deployments allowed to detect an error in the device firmware and for this reason an unplanned shipment from the UPC laboratory to the CNR-ISMAR was needed. Nevertheless, the two deployments resulted into 2445 acquired images by the DeepEye device and contextually images was also acquired, in the same field of view, with the OBSEA camera.

4. Dissemination of the results

During the TNA period the two imaging devices GUARD1 and DeepEye was tested into a relevant environment. Images were acquired by the two devices and by the video cameras that are normally part of the CPO and the OBSEA infrastructures.

Ground truth image datasets will be defined using the acquired images and new computer vision and pattern recognition algorithms will be defined and experimented on the acquired data. Moreover, the video clips acquired by the CPO Smartbay camera, are already in the process to be visually inspected by the biologists of the ADVANCE user group, and in the next months also the images acquired by the OBSEA will be analysed.

In this context, a manuscript regarding the assessment of the new imaging device DeepEye as innovative ecological device for the estimation and monitoring of both the biodiversity and the assemblage structure will be submitted to the special issue "Imaging Sensor Systems for Analyzing Subsea Environment and Life" of SENSORS:
https://www.mdpi.com/journal/sensors/special_issues/image_subsea.

In that paper, the architecture of new DeepEye imaging device will be described and the recognition results will be presented.

Another scientific article will be written based on the analysis of the CPO image data, especially regarding the fish species assemblage surrounding the observatory in a time period that include the ADVANCE deployment.

Other possible submission deals with day-night changes in species composition at Smartbay.

5. Technical and Scientific preliminary Outcomes

The project was articulated into three main phases:

1) deployment at the SmartBay facility;

2) deployment at the OBSEA facility;

3) Data analysis.

Deployment at the SmartBay facility: The GUARD1 imaging device was shipped to Galway on 3rd April 2108 and the preparatory meeting of the phase (1) took place at the Marine Institute in Galway on 11th and 12th April 2018.

The preparatory meeting was attended - for the ADVANCE user group - by Simone Marini (PI) from CNR-ISMAR, Emanuela Fanelli (PI) from Università Politecnica delle Marche - Iatly, Jacopo Aguzzi (member of the ADVANCE research team) from ICM-CSIC (Spain) and by the TNA provider team of the CPO. During the meeting, the functioning of the imaging device was explained, we decided which bracket was needed for installing the device on the CPO infrastructure, which would be the best field of view of both the GUARD1 imaging device and the CPO camera and which was the best acquisition frequency for the experiment. In particular, both the GUARD1 and the CPO camera was positioned in order to acquire images containing part of the water column and part of the seabed. The image acquisition frequency was set to one image every 25 minutes.

Due to a delay into the maintenance of the CPO infrastructure, the imaging device deployment was delayed to 27th July 2018. As a consequence the device recovery was planned on 26th September 2018 (60 days). The device was actually recovered on 29th September 2018. During the deployment, about 100 ml of water entered the GUARD1 housing and compromised the battery pack, which was consequently completely discharged in only 10 days of acquisition, corresponding to 635 images. In spite of this, the acquired images resulted of good quality and contain relevant information about the fish species present in the surrounding of the observatory. The acquired images contain also relevant information about Norway lobster's burrows and organisms in the part of the seabed framed by both the GUARD1 imaging device and the CPO camera.

Due to the battery pack and housing damage, an unplanned shipment of the device was performed from Galway to CNR-ISMAR on 09 October 2018. After further analysis a small scratch was found in the housing, near the case-back and the rechargeable battery pack needed to be replaced.

Deployment at the OBSEA facility: due to the GUARD1 damage, the new imaging device called DeepEye, released on July 2018, was sent to Vilanova i la Geltru' for performing the experiment planned in phase 2). The new DeepEye imaging device has a completely different technology from the old GUARD1 imaging device and the experiment at the OBSEA was considered as a test for assessing the hardware reliability of the the DeepEye device and for assessing its capability to acquire images useful for ecological applications.

The DeepEye imaging device was sent to the UPC laboratory in Vilanova i la Geltrù on 21st September 2018 and the preparatory meeting for the OBSEA experiment took place on the 2nd October 2018 in

Vilanova i la Geltrù. The preparatory meeting was attended - for the ADVANCE user group - by Simone Marini (PI) from CNR-ISMAR (Italy), Emanuela Fanelli (PI) from Università Politecnica delle Marche (Italy), and by the TNA provider team of the OBSEA. Similarly to the Galway meeting, the functioning of the imaging device was explained, we decided which bracket was needed to install the device on the OBSEA infrastructure, which would be the best field of view of DeepEye and which was the best acquisition frequency for the experiment. In particular, the DeepEye was positioned in order to take images in the same field of view of the OBSEA camera, both facing the artificial reef made of concrete positioned in front of the observatory. The image acquisition frequency was set to one image every 10 minutes.

During the OBSEA experiment, two deployments were performed. The first deployment started on 22nd October 2019 and finished on 5th December 2018. During this deployment 2445 images was acquired. The images resulted slightly overexposed and moreover the planned image acquisition frequency was not respected by the device. The image acquisition parameters of the device was changed in order to improve the image quality and the acquisition frequency was re-programmed. The second deployment started on 17th December 2018 and finished on 29th January 2019. The new settings of the image acquisition parameters produced well-exposed images. The DeepEye imaging device incorporates a general-purpose firmware-level image filter capable to identify which regions of the acquired image have relevant content. During the two deployments two different settings of the image filter was experimented providing good results in both the cases. On the contrary, also during the second deployment, the planned image acquisition frequency was not respected by the device. Thus, the device was shipped back to ISMAR-CNR (Italy) for an in-depth check and an error was found in the firmware device. The error was corrected and the imaging device was shipped again to Vilanova i la Geltrù on 5th March 2019. Then a third meeting took place at the UPC laboratory in Vilanova i la Geltrù and in Barcelona, at the ICM-CSIC, on 27th-29th March 2019 . The meeting was attended by Simone Marini (ADVANCE PI), Emanuela Fanelli (ADVANCE PI), Ernesto Azzurro (ADVANCE research team), Jacopo Aguzzi (ADVANCE research team) and by the TNA provider team of the OBSEA. During this meeting the device was tested and prepared for a new deployment (outside of the ADVANCE project). Furthermore, the data acquired during the CPO deployment and during the first two OBSEA deployments were discussed. The activities of data analysis were outlined as well as the dissemination activities.

Data Analysis: using the image dataset acquired by the two imaging devices, GUARD1 and DeepEye, and by the cameras installed on the CPO and the OBSEA observatories, ground truth image datasets will be defined. These datasets will be used for the definition and the validation of new computer vision and pattern recognition algorithms for fish recognition and the classification tasks. In particular, the video clips acquired by the CPO Smartbay camera, are already in the process to be visually inspected by the biologists of the ADVANCE user group, and in the next months also the images acquired by the OBSEA will be analysed.

SUBMITTED, 18 APRIL 2019