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Pipe and cable inspection in the AIRSUB project context

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1. Introduction

AIRSUB is a research project funded by the Spanish Ministry of Science and Technology whose aim is to explore the industrial applications of underwater robots. To achieve this goal, AIRSUB, with the help of industrial agents, will study different application scenarios for this technology. Then, the project will focus on three specific domains: (1) dam inspection (the University of Girona); (2) cable/pipeline inspection (the University of the Balearic Islands), and finally, (3) harbour inspection tasks (the Polytechnic University of Catalonia). The aim of this paper is to present the goals corresponding to the subproject of the University of the Balearic Islands (UIB).

Since 1997, the Systems, Robotics and Vision Group (SRV) at the UIB has focused its attention on the development of image sequence processing systems for the detection and tracking of underwater power cables. At the same time, the design and development of an AUV (Autonomous Underwater Vehicle) has been carried out. The prototype, called RAO [1], has been extensively used by the group to experiment on navigation systems and strategies in structured and controlled environments. The AIRSUB project is the next natural stage for the above-mentioned research line; that is to say, the design of an autonomous video-based cable tracker able to work in a real environment. As a natural extension, the vehicle could also be tested, with minor changes, to track any other object similar in appearance to a cable such as oil, gas or waste water pipes. Moreover, the plans for the cable tracking system include the automatic detection of the more frequent defects and anomalous situations of those equipments, including cable coverage loss and free-span. It is essential for the project to have a vehicle with a structure robust enough to reach and work at depths of almost 100 meters. To this end, the SRV group acquired a unit of the low-cost commercial ROV (Remotely Operated Vehicle) SeaLion prepared to work at 150 m depth.

Fig 1. RAO II hull, based on a SeaLion ROV.

In this project, the vehicle will be mechanically and electronically modified to transform it into a new AUV prototype which will be called RAO II (see fig 1). To succeed, the project requires a big and specialized human team working on many different tasks at very different levels, ranging from research and development to field testing and mechanical engineering. As far as research in robotics is concerned, new algorithms of control architectures, computer vision, navigation strategies, behaviours, and learning, among others, will be studied and developed.

2. Underwater cable inspection at the UIB

Underwater power cables need to be periodically inspected to prevent failure caused by the loss of their external cover. On the one hand, marine stream, waves or even seismic activity can cause important changes in the seabed where a cable lays. As a result, the cable can become hanged between two rocks, giving rise to an anomalous situation known as free-span. Free-span is not desirable since can lead to a cable failure due to both the cover rigidity and a larger likelihood of an anchor hooking the cable. On the other hand, the corrosion affecting the cable due to the loss of the cover caused by the impact of anchors, fishing nets trawling, marine flora growth or shark attacks accelerate the ageing of the cable. Figure 2 shows both free-span and cover loss. Nowadays, the preventive inspection of underwater cables is performed by divers or by ROVs. Obviously, the automation of any part of the inspection can greatly improve the speed, the safety and the cost of the inspection program.

Fig 2. Free-span and cover loss defects.

The first step to automate the cable inspection process is the tracking of the cable. Thus, since our group started to work on underwater vision, some algorithms for visual cable detection and tracking have been developed [2]. These algorithms have been successfully tested on real image sequences thanks to the video recordings transferred by the electrical company GESA-Endesa. The sequences corresponded to the electric power cables settled more than 25 years ago between the Balearic Islands and were recorded using a ROV. Frames of these sequences are shown in figure 3.

Along the last years, a control architecture specially designed for the visual guidance of an AUV has also been developed [3]. This architecture uses some new navigation strategies and has been tested both on a realistic simulator and on the URIS AUV at the University of Girona facilities, as can be seen in figure 4 [4].

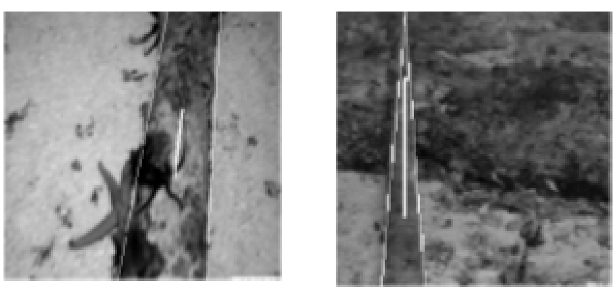

Fig 3. Typical images of power cables on the seabed.

3. AIRSUB tasks planning

As a consequence of the above-mentioned research, the main target we plan to obtain during the AIRSUB project is a fully autonomous underwater vehicle able to track and inspect electrical power cables. Because of its morphological similarity, the ability of the vehicle to inspect waste water or gas and oil pipes will also be considered.

The main objective of AIRSUB comprises the following tasks:

·Cable detection and tracking improvement. Texture analysis and video sequence edge detection techniques will be used to design new algorithms. Their performance will be compared to those used up until now. A complexity analysis has also to be done to ensure a real time execution. Algorithms for the detection of cable defects will also be developed at the same time.

·Control architecture. New strategies for 2D and 3D navigation will be added to ensure the missions conclude safely. Learning techniques applied to some architecture parameters will also be added.

·New vehicle. The SeaLion hull will be mechanically and electrically adapted to become the RAO II. Besides, new sensors will be added, especially SONAR, DVL and INS units.

·Graphical interface. A graphical tool to monitorize the vehicle during the development stage is needed. This remote control panel will be used to acquire data in real-time and to adjust low-level control parameters.

·Simulator. The simulation platforms of the UIB and UdG will be unified. At the same time, we will adapt the simulator and the RAO II vehicle to work in HIL mode (hardware-in-the-loop).

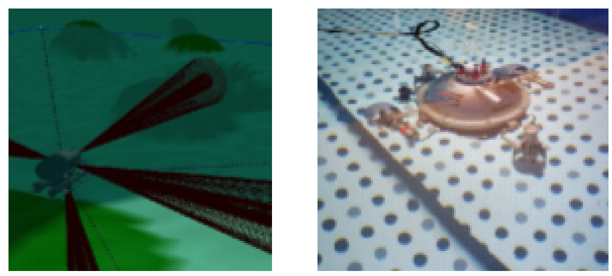

Fig 4. NemoCat simulator and cable tracking testing at Universitat de Girona facilities.

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