Dynamic control of a chain of mini-ROV

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Thesis subject

Recent advances in onboard technology, miniaturization of sensors and decreasing costs have accelerated the development of mini underwater drones. Despite the loss of performance compared to current operational UAVs, their low weight and size are interesting because they can be deployed by a single person from small boats without expensive and cumbersome launching or recovery systems, which would require large vessels and a full crew.

The cable that connects the ROV to the boat at the surface remains to date the only way to communicate a large volume of information underwater, as electromagnetic waves are absorbed from the first centimeters. While for large industrial ROVs, of the working class type, the drag of the umbilical is easily countered by the mass and engine power of the system, this is no longer the case when considering small, low-cost devices. This is even more true when you move away from the boat and approach the coastal zone called surf zone with strong current and swell. However, this is the destination zone for these mini-robots that can evolve in shallow water. Their mission therefore requires them to be particularly exposed to marine disturbances. In order to help a mini-ROV to counter the disturbances of its umbilical, the COSMER laboratory is working on the concept of robot ropes. The idea is to add mini-ROVs regularly on the umbilical so that they erase in a coordinated way the disturbances of the cable on the leading robot. This also allows to position the cable in space taking into account the obstacles and to avoid that it gets tangled in the systems or on itself.

This thesis is therefore part of one of the mobile robotics themes of the COSMER laboratory, namely the consideration of the influence of the umbilical on the manoeuvre of a light ROV. This theme has already been addressed in previous works whose object was the estimation of the configuration of the umbilical in order to estimate the position of ROVs composing a string of ROVs[1]. A second thesis is in progress at COSMER. It deals with the localization of the rope by visual SLAM techniques. At this stage, it is possible to estimate in real time the position of the rope elements in a map of the environment. The next step is to command the rope to move towards a goal and avoid obstacles in these reconstructed environments.

The work we now propose focuses on the control of the robot rope as a single system, composed of actuated robots and passive rope portions. The objective is to propose a control that takes into account the specific dynamics of the rope, including modeling of the gear dynamics and the cable dynamics by damping platooning effects (accordion effect of vehicle trains) and rejecting external disturbances, such as currents in the water body – see for example the robot catenary [5]. We will place ourselves at the intersection of robotics and control theory. The implementation of adaptive techniques [4], or techniques related to reinforcement learning could also be considered.

Objectives : To contribute to the problem of dynamic control of tethered ROVs by proposing observers and commands adapted to these constrained flotilla systems

Methods : Predictive control, Dynamic Visual Servoing, Optimal Planning, Robust Controls (e.g. adaptive L^1 law inspired by [4]), experimental implementation.

Key words : ROV string ; control theory ; underwater robotics ; underwater vision.

Supervision and material conditions for the PhD student : The supervision will be provided by N. Boizot (MdC, HDR, LIS) and Claire Dune (MdC, COSMER). These two laboratories are geographically close. The PhD student will be hosted in one or the other laboratory according to the needs of the thesis and will benefit from a workstation as well as the experimental equipment of the COSMER robotics laboratory. The ED548 calls for proposals will provide the opportunity to organize scientific visits (conferences, workshops, specialized schools, etc.). The student will regularly participate in test campaigns at sea or in partner test centers (CEPHISMER, IFREMER).

Expected Skills Expected skills are those in linear and non-linear control, robotics/underwater robotics, with an interest in knowledge of machine learning techniques. Languages that must be mastered by the candidate are Python, C or C++. Skills in ROS would be appreciated. The successful candidate should have good research methodology skills, writing and synthesis skills in English, and a taste for field experiments in underwater robotics.

0.1 Contact person(s)

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0.2 How to apply

Before June 10th, fill in this online form: https://forms.gle/1418LD8hrv7WVnP88

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