A 4G robotic platform for shallow water operations
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ABSTRACT

A prototypical robotic platform that consists of a small autonomous surface vehicle (ASV) and of a micro-ROV, connected by an umbilical, is described. 4G internet connection makes it possible to operate the platform from remote location. The operator can concentrate on guiding the micro-ROV by means of visual data, while the surface vehicle automatically coordinates its movements with those of the micro-ROV. Small dimensions, low costs and easiness of use make the platform an effective tool for low-budget survey in shallow water. The mechatronic characteristics of the platform are illustrated and discussed, together with the results of functional tests.

KEY WORDS: marine robotics; remotely operated vehicles; autonomous surface vehicles; maritime communication; 4G mobile broadband.

INTRODUCTION

Hybrid robotic platforms that consist of an Autonomous Surface Vehicle, or ASV, and a Remotely Operated Underwater Vehicle, or ROV, are a very effective solution for inspecting underwater structures in e.g. harbor areas, rivers, natural and artificial lakes. The ASV acts as a bridge for communication with a remote station, that in this way can receive data from the ROV, avoiding the necessity of a supply vessel to operate the ROV (Scaradozzi, Conte and Sorbi, 2012; Conte et al., 2016). Examples of cooperation between autonomous surface vehicles and unmanned underwater vehicles (UUV) in hybrid robotic platforms have been considered in previous paper. In (Pascoal et al., 2000; Healey, Pascoal and Santos, 2002; Ferreira et al., 2006) an ASV and an UUV are deployed and managed independently and cooperation consists in communicating through an acoustic link to exchange information and commands. The ASV serves as acoustic relay between the AUV and a supply vessel. In (Djapic and Nad, 2010), an ASV is used to carry and deploy an AUV in a mine counter-measures applicative scenario. A robotic platform consisting of an ASV that is capable of deploying and recovering an ROV has been first considered in (Conte, De Capua and Scaradozzi, 2016) and more recently in (Gray, Schwartz and Anglerfish, 2016; Sarda and Dhanak, 2017; Jung et al., 2018; Lindst, 2018). From a commercial point of view, the C-Worker platforms of L3 Technologies have the above-mentioned characteristics and OceanScan-MST developed a device called Manta Gateway that, mounted on a buoy or ASV, acts as a bridge between Wi-Fi, mobile broadband, Iridium communications and acoustic signals for long-range underwater transmission.

A possible drawback of hybrid robotic platforms that couple, in their mechatronic and functional structure, surface and underwater vehicles is the fact they may be costly, complex to operate and logistically demanding. In this paper we describe a prototypical platform that overcomes these limiting characteristics. The present work continues the project started in (Conte and Scaradozzi, 2020) to develop a low cost, highly manageable robotic platform that integrates a small ASV and a micro-ROV. The prototype developed in the previous work has been totally redesigned in its mechatronics structure, increasing slightly the dimensions of the ASV, and optimizing the internal components and the control system. The most important feature of the new platform is the possibility of communicating over long distances thanks to a 4G router. The choice of 4G technology for communication is motivated by the fact that coastal and harbor areas, where the platform is supposed to be employed for inspecting underwater structures, have generally a very good 4G coverage. In addition, the cost of devices is low and the reliability is high.

The platform consists of an actuated buoy, as surface component, and a micro-ROV, as underwater component. The buoy and the micro-ROV are connected by an umbilical and the platform is linked to a shore control station by a 4G mobile broadband connection.

Construction costs are low and the platform can be operated efficiently in a very simple way by a single operator who guides the ROV from a remote control station, using visual data from an on-board camera and navigation data from on-board instruments. The buoy automatically follows the (projection on the water surface of the position of the) ROV, so to keep the relative distance within a given threshold as long as the ROV maintains a given depth.

The paper is organized as follows. In Section “Mechatronic structure”, the general structure of the robotic platform is described. In Section “Control interface”, the characteristics of the graphical user interface are briefly outlined. The Section “Communication” describes the structure of the communication link, that employs 4G technology and internet, between the control station, the buoy and the micro-ROV. The Section “Experimental tests” briefly describes the tests that have been performed to assess viability and efficacy proposed solutions. The results of the work are summarized in the Section “Conclusion”.

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