ABSTRACT

Robotic structures that couple autonomous surface vehicles and unmanned underwater vehicles in integrated structures with various levels of cooperation provide interesting solutions to the problem of developing efficient, versatile and cost effective tools for exploration, monitoring and exploitation of the underwater environment. In this paper we describe the development and preliminary field testing of the surface unit of a robotic platform consisting of an ASV that can automatically deploy and recover a small remotely operated vehicle. The main advantage of such structure is that it makes possible direct guidance of the micro-ROV from a remote shore station. This goal is achieved by exploiting two-ways transmission of data and commands through the umbilical and a wireless link between with a shore-ground station. In this way, pilots can experiment telepresence in the underwater environment, avoiding the need of expensive and logistically demanding manned supply vessel. The vehicle is a small aluminum hull boat, equipped with a steering outboard electric motor. Its robotic structure is organized as a multi-agent system in the ROS framework. The use of commercial-off-the-shelf components and the choice of a multi-agent ROS architecture are a mean to reduce costs and to assure performances, modularity and versatility. Preliminary field tests concerning basic functionalities in supervised mode and in autonomous guidance mode have been performed in order to assess the basic functionalities of the system and their results are illustrated and discussed.

KEY WORDS: ASV, ROS; Multi-Agent System; GNC; control; ship; ROV.

INTRODUCTION

In the development of robotic platforms for marine applications, it is important to address performances, as well as versatility, easiness of use and costs. In order to satisfy these requirements, in several cases robotic architectures may exploit cooperation and integration between Autonomous Surface Vehicles (ASV) and Unmanned Underwater Vehicles (UUV) of various kinds. In seabed surveys and data acquisition, for instance, surface and underwater vehicles may cooperate simply by exchanging information and commands that, facilitating localization and navigation, guarantee coverage and accuracy (Healey et al., 2002; Pascoal et al., 2000; Ferreira et al., 2011). In other applications, autonomous surface vehicles may be used to carry and to deploy underwater vehicles in designated areas to perform specific exploration or intervention tasks (Djapic and Nad, 2010).

This paper presents the development of a small, low-cost, prototypical ASV, conceived to be a component of an integrated platform, together with a micro Remotely Operate Vehicles (micro-ROV). The platform, whose structure is depicted in Fig. 1, includes, together with the ASV, a micro-ROV and a shore-ground station. The ASV is designed to deploy/recover the micro-ROV, which is remotely operated, through a radio link and the umbilical, from a shore-ground station. The platform can be employed for exploration, monitoring and light intervention purposes in the underwater environment, allowing telepresence on the spot of interest and direct guidance by the operator without the costs of manned supply vessels.

The main tasks which the ASV must be able to perform are autonomous navigation with the aid of navigation sensors (GPS, compass, Inertial Measurement Unit (IMU)) and formation keeping, with the aid of an USBL positioning system, with the micro-ROV, while the latter is freely guided by a pilot. The Navigation, Guidance and Control (NGC) system that takes care of those tasks and that governs all on-board apparatus for navigation, management of the micro-ROV and communication is organized as a Multi Agent System (MAS) in the ROS framework, as described also in Conte (2015b). The MAS structure has the advantage of assuring a high level of autonomy and scalability, allowing self-organization of components (agents) and plug-and-play functionality. The underlying ROS infrastructure, on the other hand, assures modularity, rapid prototyping, the possibility of employing existing open-source software modules for robotic applications and easy interfacing with other ROS structures. Modularity and scalability of the structure let the ASV operation to switch seamlessly from autonomous control, to manual control (by an on-board operator) or remote control. Moreover, the use of components-