A robotic platform for underwater assisted manipulation

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ABSTRACT

This paper describes the structure of an innovative robotic platform that integrates a small work-class ROV, a micro-ROV and a dexterous manipulator. The main feature of the robotic structure is to facilitate underwater tele-manipulation by assisting the operator in piloting the manipulator end-effector and by implementing monitoring procedures that increase situation awareness. Automatic control solutions and guidelines in the development of the robotic platform are illustrated and discussed.

KEY WORDS: Underwater robotics; underwater manipulator; ROV, marine systems.

INTRODUCTION

In underwater intervention tasks, manipulation is generally performed by means of tele-operated robotic manipulators, with multiple degrees of freedom, that are mounted on an ROV. Environmental conditions and structural characteristics of the integrated ROV-manipulator robotic platform can make underwater manipulation a very difficult and demanding task. In order to reduce its complexity, advanced control solutions that give priority to the task of guiding, positioning and operating the manipulator’s end-effector have been developed (see Simetti, Casalino, Torelli, Sperindè, Turetta, 2014), where an autonomous controller of that kind, that can be easily adapted for tele-operation, has been described. In control configurations of that kind, the guidance and control system of the ROV and of the manipulator assist the operator by taking care autonomously of governing the robotic platform in accordance with the motion commanded to the end-effector. Although quite effective, this solution has the disadvantage of depriving the operator of the direct control on the movements of the robotic platform and of the vision and acoustic systems that are mounted on it. As a consequence, the operator is forced to work monitoring the scene (by optic or acoustic devices) from a non-stationary point of view, whose motion is not under his direct control and that, in practice, results to be scarcely predictable. The use of vision or sonar systems mounted on the end-effector is not always viable and, in any case, it is not very effective, since in this way the scene they capture does not include the end-effector.

In order to overcome the above described difficulties, we propose in this paper an innovative robotic platform that integrates the ROV/manipulator structure with a micro-ROV (Conte, Perdon, Scaradozzi, Vitaioi, Zanoli, 2011). The micro-ROV is tethered to the ROV as an appendix by a short (15m) umbilical and it carries a video-camera and possibly a sonar imaging system. By these devices, the operator get a vision of the workspace from an external point of view that does not change position when the ROV/manipulator structure moves to facilitate the operation of the end-effector. The micro-ROV control system is integrated into the overall control system of the robotic platform, in order to let the operator free from additional tasks and to guarantee that the micro-ROV automatically keeps the external point of view in a fixed position in presence of disturbances (e.g. due to the environment or to the umbilical) by visual and/or acoustic feedback.

In this paper, we briefly describe the basic components of the system that is currently under development in the framework of the Research Project “Phantom Underwater Modular Arm-PhUMA” at the marine laboratory SEALAB of the Interuniversity Institute “Integrated System for Marine Environment” (ISME) and of the CSSN of the Italian Navy in La Spezia, Italy, and we illustrate the guidelines that we are following for developing the robotic platform through adaptation and integration of mechatronics elements and specific control solutions.

The objective of the project is the construction of a robotic system that couples versatility with usability for light intervention up to 100m depth, that requires small logistic support to be deployed and operated and that can be managed by a single operator.

The paper is organized as follows. First, the mechatronic structure of the robotic platform is described, together with the architecture of its control system. Then, the ROV/manipulator control structure for tele-manipulation is described, on the basis of the control structure developed in (Simetti, Casalino, Torelli, Sperindè, Turetta, 2014), for automatic control. The characteristic of this solution is the fact that it let the operator to guide the manipulator’s end-effector to a desired position by executing automatically the motion of the ROV and the relative motion of the manipulator that are required for achieving that...