Short range full ocean depth underwater precision 6DOF position/motion tracker for autonomous manipulation

G. Marani, L. Gambella, J. Yuh, S. K. Choi

University of Hawaii at Manoa
Mechanical Engineering Department
Honolulu, Hawaii

ABSTRACT

This paper presents the study of an underwater position sensor for autonomous robotic manipulation in AUV. Based on ultrasonic technology, the goal is to acquire the generalized position (rotation and translation) of the target with the necessary accuracy required by a generic real-time intervention task. The ultrasonic tracker utilizes high frequency sound waves to track a small probe by the triangulation of several transmitters and receivers: this method is inspired to a combination of time-of-flight measurements and phase detection in order to increase the accuracy. Experimental tests have been performed using the robotic manipulator of SAUVIM, a Semi-Autonomous Underwater Vehicle for Intervention Missions.

KEY WORDS

underwater intervention; autonomous manipulation; sonar; localization; tracking, ultrasound, AUV, ROV.

INTRODUCTION

Many intervention tasks in the underwater environment are today performed by manned submersibles or Remotely Operated Vehicles (ROVs) in teleoperation mode. Autonomous Underwater Vehicles (AUVs) with no physical link and with no human occupants permit operating in areas where humans cannot go, such as under ice, in militarily denied areas, or in missions to retrieve hazardous objects. However, the low bandwidth and significant time delay inherent in acoustic subsea communication are a considerable obstacle to remotely operate a manipulation system, making it impossible for remote controllers to react to problems in a timely manner.

The key element in improving underwater intervention capability in AUVs is autonomous manipulation. It is a challenging technology milestone, which refers to the capability of a robot system that performs intervention tasks requiring physical contacts with unstructured environments without continuous human supervision. Today, few AUVs are equipped with autonomous manipulators. SAUVIM (Semi Autonomous Underwater Vehicle for Intervention Mission, University

of Hawaii, Fig. 1) is one of the first AUVs capable of autonomous intervention (Yuh, Choi, Ikehara, Kim, McMurty, Ghasemi-Nejhad, Sarkar and Sugihara, 1998, Yuh and Choi, 1999, Ridao, Yuh, Batlle, Sugihara, 2000).

SAUVIM is equipped with a 7 degrees of freedom electro-mechanical robotic manipulator, MARIS (Marani, Kim and Yuh, 2002, Marani, Kim, Yuh and Chung, 2003). This work has been done for enhancing the capabilities of the autonomous manipulation subsystem of SAUVIM.

Autonomous manipulation systems, unlike teleoperated manipulation systems that are controlled by human operators with the aid of visual and other sensory feedback, must be capable of assessing a situation, including self-calibration based on sensory information, and executing or revising a course of manipulating action without continuous human intervention.

At the task execution level, the system must be capable of acting and reacting to the environment with the extensive use of sensor data processing and the most important aspect is the target localization. A common scenario for a generic autonomous manipulation intervention is a situation where the vehicle is station-keeping while the arm performs the required task. In the above configuration, the vehicle's position and orientation are maintained with the aid of several different sensors, which may have considerable measurement noise and different accuracy. For example, Hydroacoustic Position Reference systems (like Long Base Line or similar sensors) are often used to measure the position in X, Y, and Z (or altitude) in Earth-fixed coordinates and their outputs have an accuracy of about 1m. Position in Z is also measured by a depth sensor that gives much more accurate output.

Orientation in x, y, and z (vehicle coordinate) could be measured by sensors like Inertial Measurement Unit. We can also use other sensors such as Doppler Velocity Log and Inertial Navigation System for redundant or additional measurements such as velocity and acceleration. We often use a filter like Kalman to estimate other variables such as velocity from direct measurements from the sensors. However, all sensors experience a certain level of random noise in their measurements. Therefore, the absolute position and orientation measurements of the vehicle, especially in X and Y, have an insufficient accuracy for a precision manipulation task. Additional