

AUV for Shallow Water Applications – some Design Aspects

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ABSTRACT

This paper describes the design aspects of an Autonomous Underwater Vehicle (AUV). The description includes detail mechanical design, software architecture, controllers and integration of various sensors. This AUV has been designed for a depth of 150 m with multi-thruster actuation for shallow water applications. Several sensors are used as feedback devices for the navigation, guidance and control of the vehicle. The AUV is also equipped with camera, CTD and side scan sonar as payload sensors. The simulation results have been discussed along with preliminary trial of the system.

KEY WORDS: AUV; design; navigation; trajectory tracking; control.

INTRODUCTION

Autonomous underwater robotic systems, designated AUVs, are gaining importance owing to their embedded advantages for applications like seabed mapping, coastal surveillance, mine countermeasure, and oceanographic measurements during adverse weather conditions. With no physical cable connection to the surface control station and possessing onboard intelligence and energy supply, an AUV carries payload for carrying out a specific task. The configuration and payload of an AUV depends on mission requirements. The communication is hybrid in nature – RF while on surface and acoustic while underwater. Mission requirements and the use of payloads sometimes dictate the size and configuration of the AUV that can both be open or close frame. The motion in various directions of AUV are obtained through thrusters or/and controlled surfaces/hydroplanes/fins (Song and Folleco, 2003; Licht, Polidoro, Flores, Hover and Triantafyllou 2004; Barros, Pascoal and Sa, 2004).

Autonomous intelligent control and navigation play important roles in the efficient AUV operation. The AUV takes certain decisions intelligently for execution of the mission and for situation-dependent dynamic obstacle avoidance. Different researchers are using various approaches for proper AUV navigation through efficient path planning embedded with proper control of actuation systems. (Lam and Ura, 1996; Craven, Sutton and Burns, 1998; Wang, Lane and Falconer, 2000; Kim and Choi, 2004; Doherty, 2004; Petres, Pailhas, Patron,

Petillot, Evans and Lane, 2007; Bogosyan and Arabyan, 2007). In majority of the cases, the mechanical design as well as software codes are not modular in nature (Madhan, Desa, Prabhudesai, Desa, Mascarenhas, Maurya, Navelkar, Afzulpurkar, Khalap and Sebastiao, 2006; Desa, Madhan, and Maurya, 2006).

AUVs are expensive, and dedicated teams of scientists work together for years to make the system seaworthy. Before subjecting the AUV to uncertain turbulent sea environment, it is preferable to simulate performance of various subsystems through appropriate mathematical modeling and finalizing the hardware and software level implementation details. Systematic design approaches have to be followed for the development of an efficient seaworthy AUV.

The present paper addresses the overall design criteria followed for the development of an AUV capable of working in shallow depth of 150 m for seabed mapping and data collection. The paper also highlights the salient features of the hardware and software with some implementation details.

DESIGN ASPECTS

Key parameters determining AUV characteristics are: maximum working speed, depth of operation, payload capacity and mission time, which are highly interrelated. Proper judicial selection of parameters is therefore very important. The various issues considered during design of the system being discussed are detailed below.

Configuration – The important parameters of the AUV with respect to shape and size are: minimum drag, minimal flow separation, improved vehicle stability adequate space for accommodating all necessary hardware. From the simple perspective of drag reduction, a form that promotes laminar flow within the boundary layer constitutes the appropriate choice. Taking this into consideration, a dome shaped fore a hull form aft has been chosen.

Skin friction and form drag contributes to the overall vehicle drag. Friction drag varies with speed and exposed surface area. Form drag is a function of how well the hull shape minimizes flow separation. It is estimated based on the frontal area and is usually larger than the friction drag for typical AUV configurations. Longer and slender shapes are therefore better for frontal drag. Test results show that streamlined form with length to diameter ratio in between 7 and 10 performs well to minimize drag. The various hydrodynamic coefficients need to be calculated based on the current shape and size of