Optimized Adaptive Control on Dual Buoyancy System for application in Underwater Gliders

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Abstract: The control on the navigation and guidance procedures applied to underwater gliders are based in the combination of the effect of variation of the vehicle buoyancy in association with internal masses movements. The buoyancy control subsystems is mostly based in oil fillable external-bladders which can increase the vehicle net volume in a small amount of near ±0.5-0.8%. Internal masses are used for attitude control of the vehicle. Nevertheless, most of these systems generate low values on the vehicle dynamics which make difficult the use of low cost navigation sensors. With the aim of advance in the use of off-the-shelf electronic components for application in the control of all the previous mentioned subsystems, it has been designed a multistate control for application in the underwater glider Alba-14. Because limited accuracy of low cost MEM electronic sensors, it has been considered this system for application in gliding based underwater vehicles with higher dynamic capabilities than the standard ones. A multimode hybrid control system associated to the multiple buoyancy based propulsion technique implemented in the Alba-14 glider is proposed in this paper.

Keywords: Hybrid Underwater glider, Adaptive Control, Marine Robotics, Arduino, AUV.

I INTRODUCTION

Several methods have been implemented for application in the control of navigation of underwater gliders. These vehicles have a particular system of propulsion based in variable buoyancy. Heading angle is controlled in some designs by the effect of roll angle in combination with surge speed and a certain angle of attack [1]. Since no direct speed measurements are usually available, estimations by the application of observer-controller combination should be applied in base of the measurements from the Inertial Unit (IMU) integrated gyro and accelerometers. By means of different heading control systems (roll attitude control by internal moving mass or movable tail fins), underwater gliders can adjust their heading for following the desired course. With masses of 50 kg around on most common gliders [1], a variation of buoyancy to mass factor of 0.4-0.8 % low effective velocities of 0.25 m/s derive in low values of hydrodynamic forces and then, important limitations in maneuverability.

With the aim of developing a navigation control for underwater glider based on off-the-shelf sensors, additional problems related to the low level of accuracy related to low dynamics as well as noise level should be considered. For dealing with these limitations, adequate robust control procedures should be developed in order to minimize the undesired effects of the mentioned high noise level present in the inputs and the leakage of accuracy associated to off-the-shelf sensors.

II MULTIMODE ADAPTIVE CONTROL

For dealing with different situations a multimode hybrid control has been designed for application in the hybrid underwater glider Alba-14 [2]. Adaptive capacity to a specific feature or event of interest requires modifications on the navigation parameters and the vehicle behavior by means of the application of a kind of deliberative control framework [3].
Because the limitations in maneuverability related to buoyancy effect vehicles, not all the desired maneuvers are feasible. Hybrid propelled gliders could deal temporarily with these situations but for a limited period of time, depending on the internal batteries capacity [4]. For this reason a prioritizer mode based acoustic sensors [5] can be of interest in adaptive improved control for reacting against unexpected events as for example, marine traffic allowing the glider to trigger avoiding maneuvers autonomously.

Among other there are some other scenarios where self-adaptive behavior in gliders can be of interest: navigation in turbulent water or mixing areas with their associated flow fluctuations, areas near river mouths because changes in density and rotational flows, navigation in fiords during seasons of melting ice or high density saline plumes coming from inland saline lagoons [6].

III MICROCONTROLER

From the first application on the Alba series of glider vehicles [7], the control of internal functions has been relied in Arduino and compatible boards and peripherals, which have demonstrated it viability even for application in other robotic projects [8][9]. Several are the advantages of using Arduino as a control platform in underwater vehicles and robotics in general. Due to the high number of users and because its concept based in open source, the success of Arduino systems gave to count with millions of collaborators worldwide that can contribute to improve routines and libraries and sharing knowledge with mutual benefit.

Alba propelled underwater vehicles project [10] has been considered from the beginning to contribute in the way of demonstrate the feasibility of such architecture. Based in Arduino family boards and more powerful compatible further developments like the Intel Galileo®, it is one of the goals of this project to demonstrate the feasibility of its application in the design of useful unmanned marine vehicles.

IV CONCLUSIONS

The applications of low-cost components and of-the-shelf devices can be useful even for advanced applications when no extremely high level of accuracy is required.

Similarly to other interesting proposals [11] an optimized adaptive control system based in multiple states can be implemented onboard the vehicle for using these components on an Arduino compatible microcontroller. This configuration can be useful for dealing with different unexpected situations in long term deployments. Increased computing capacity in Arduino compatible boards like the Intel Galileo considered in this project can provide important
advances as a test-bed for applications of advanced navigation control systems and high computing demanding complementary functions.

V FUTURE WORK

Future works include the implementation, simulation and real test of all modes of operation of the vehicle and testing the autonomous transitions among the pre-established modes of operation. Tests and trials with the prototype of the Alba-14 glider in a confined environment are scheduled for this year. Additional open water trials are expected to be conducted afterwards for validation of the procedures and different sub-systems in the real world.

REFERENCES