Simulation of Depth Controllers for Underwater Glider

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Abstract - *Comparison of depth control schemes for an underwater glider is presented. Considered underwater glider is a torpedo shape and has a controllable buoyancy bag and a movable center of gravity. While a underwater robot with propeller thrust needs lots of energy to surge, an underwater glider requires small amount of energy to inflate/deflate buoyancy bag and/or to move battery pack. Through the zig-zag gliding, underwater glider moves forward. The depth of the underwater glider is controlled by changing the buoyancy mass and the attitude, by changing center of gravity. The performance of PID controller, LQR controller, and Lyapunov nonlinear controller is shown by simulations using Matlab/Simulink.*

Keywords: Underwater glider, control, Matlab, Simulink

1 Introduction

Underwater glider is a sort of an autonomous underwater vehicle which operates without the tether line connected to the mother ship. Compared with the conventional underwater vehicle with propeller thrusters which require a considerable amount of energy, the underwater glider consumes less energy because it moves by the vertical zigzag motion by using the energy only to inflate the buoyancy bag and move the battery pack in the hull shown in Fig. 1. Therefore, it has a longer operation time and a wider operation range than the conventional autonomous underwater vehicle has. In this process, the underwater glider controls its depth and attitude by changing the buoyancy mass and the center of gravity, respectively. For the underwater glider to go downward, for example, the center of gravity needs to move toward the head of the vehicle while the buoyancy bag is inflating to absorb outside water.

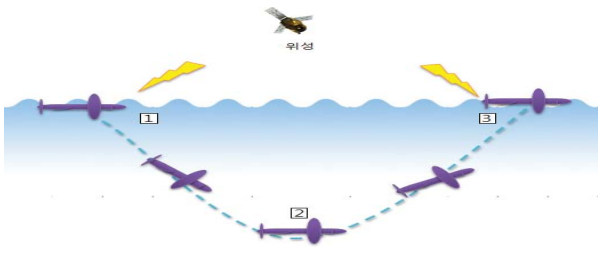

Figure 1 Basic principle of a conventional underwater glider.

Compared with the conventional underwater glider with long wings on its hull, we consider a torpedo shaped autonomous underwater vehicle equipped with a moving center of gravity and a controllable buoyancy bag in its hull as shown in Fig. 2. The hybrid underwater vehicle is to combine the gliding function into the conventional autonomous underwater vehicle. For example, the proposed hybrid underwater vehicle can approach to the far location without propeller noise and then, may operate as conventional autonomous underwater vehicle. The hybrid glider is simulated by using Matlab/Simulink. The dynamics of the underwater vehicle and the notations are well introduced in [1-4] and [5], where 12 state variables are used to describe the motion and the attitude of the vehicle in 6 degree of freedom.

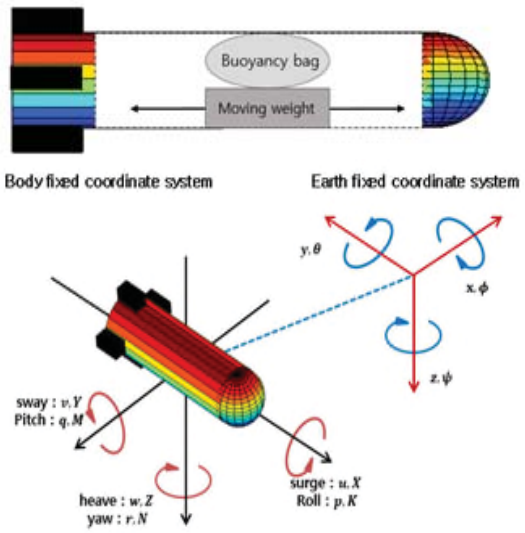

Figure 2 A hybrid underwater vehicle with a controllable buoyancy bag and a moving center of gravity.

2 Controllers of the hybrid underwater glider

For the hybrid underwater glider to glide stably the attitude is controlled by the position of the center of gravity and the depth is controlled by the inflation rate of the buoyancy bag.

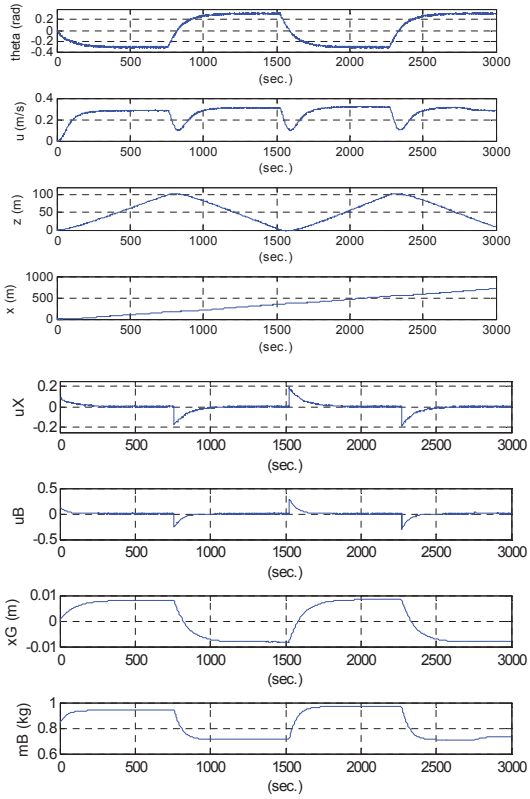

Figure 3 Control results from PID controller.

2.1 PID controller

PID controller does not require a sophisticated dynamics of the underwater vehicle. Only three gain values for tuning the PID controller were found by trial and error approach. Control results are shown in Figure 3.

2.2 LQR controller

Through the linearization of the underwater glider dynamics on the operating point, an LQR controller was developed. Solving the Ricatti equation is necessary to obtain the respective gain values satisfying a given performance index. Control results are given in Figure 4.

3 Conclusions

This paper demonstrates the performance of a simple PID controller and an LQR controller by the Matlab/Simulink simulations. Both of the controllers can maintain the gliding condition.

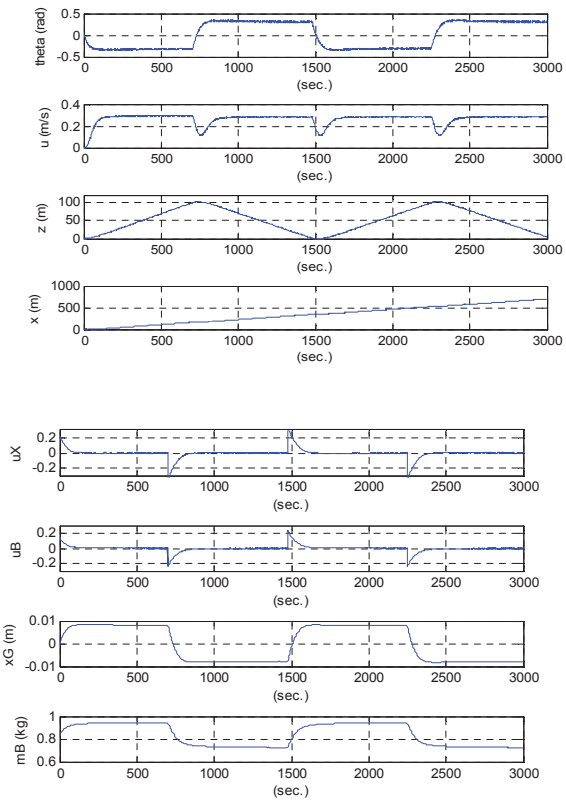

Figure 4 Control results from LQR controller.

4 References

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