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Development of a Motion Control System for Underwater Gliding Vehicle

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ABSTRACT

The authors have been developing a gliding type underwater vehicle, an autonomous unmanned underwater robot. The motion of the vehicle is not limited by a tether cable and it can cruise freely in the ocean, using the lift of a wing and changing its weight in the water, repeatedly descending and ascending. It does not have a thruster. An untethered underwater vehicle cannot be supplied energy by a support ship and must be equipped with sufficient energy in its body. In this point of view a gliding type vehicle has an advantage because high propulsive efficiency can be expected using the gliding method (Ura, 1989; Ura, 1990).

This paper presents a motion control system using an air pump to change the body weight in water. The depth of the vehicle is controlled by a controller using a depth sensor. The system controls the depth of the vehicle using a buoyancy changing mechanism. The attitude of the vehicle is also controlled by ailerons and a device that changes the center of gravity of the vehicle.

KEY WORDS: Underwater vehicle, Glider, AUV, Motion control

INTRODUCTION

Various environmentally-related issues of the earth including acid rain caused by the mass consumption of fossil fuel and global warming due to the cutting down of rainforests are pressing problems. These phenomena are causing enormous damage to our life.

To prevent further advancement of these problems and to clarify the mechanism of climate change, details of the ocean environment must be examined. It is especially essential to understand the change of substance, heat and momentum in the ocean mixed layer that affects mutual interference between the atmosphere and the ocean (Koterayama et al, 2000a; Yokobiki et al, 2000b).

The authors have been developing an autonomous gliding type vehicle for ocean observation as an effective tool for the purpose. It cruises in the ocean repeatedly descending and ascending by changing the buoyancy of its body. It also has a center of gravity controller and a pair of ailerons. These devices enable the attitude of the vehicle to be controlled. The vehicle has the following characteristics:

- It cruises freely without a tether cable.
- Operation costs are reduced because it does not need a special backup mother vessel.
- The autonomous vehicle endangers no human.
- The gliding type propulsion is highly energy efficient.

For these reasons, the gliding vehicle is a device for which there is great hope for ocean observations.

This paper describes the development of a motion control system for the vehicle using a depth sensor and an accelerometer. The accelerometer is used to measure rough attitude angles of the vehicle. The system includes two controllers. One is for the gliding motion and is composed of a depth sensor and air chambers. The buoyancy of the vehicle is adjusted by an air pump which changes the volume of the air chambers. The other is to control the pitch and roll angle of the vehicle and is composed of accelerometers, a center of gravity control device and a pair of ailerons on the main wing of the vehicle.

UNDERWATER GLIDING VEHICLE

In previous research (2004) body types were examined based on numerical simulation of the vehicle's motion. Tank experiments were also carried out using a small scale model equipped with a buoyancy control device to confirm the effectiveness of the gliding propulsion method.

In this paper, the authors report the attempt to develop a motion control system for actual use. The vehicle is composed of a body, a main wing and a vertical tail wing as shown in Fig. 1. The principal dimensions are shown in Table 1. The origin of the coordinate system is positioned at the center of the body as shown in the figure.