System analyses and motion control of a towed underwater vehicle

［修士］

修士学位論文内容要旨
Abstract

専　攻 Major	Marine System Engineering	氏　名 Name	Asuma Minowa
論文題目 Title	System analyses and motion control of a towed underwater vehicle		

This thesis presents system analyses and a motion control method for a towed underwater vehicle (TUV) which has movable wings at the center (main wing) and rear (tail wing) to actively control its attitude and depth. In recent years, some environmental problems such as global warming have become serious and, accordingly, importance of exploration of underwater environments have increased. A TUV is a kind of underwater vehicle which does not have a thruster inherently and is towed by the mothership to move. In the past, a lot of works on control problems of TUVs have been conducted, however there are few ones which address the system nonlinearity directly. Hence, our objective is to develop a motion control method for such a TUV taking account its nonlinearity.

First, the dynamical model in the lowest-order case is derived by using the Lagrange equations of motion and the principle of virtual work. To obtain the model, we employ two different approximate methods for the cable: the one is based on the lumped-mass method, and the other one regards the cable as a rigid bar.

Next, we locate an equilibrium point of the system such that attitudes of the vehicle and the main wing are horizontal. The linearization of the system around the point is obtained, and some basic characteristics of the system, i.e., stability, controllability and observability are analyzed. Based on these analyses, a linear state-feedback controller is initially designed to regulate the system to the equilibrium. Then, to develop output-feedback controllers, two types of nonlinear observers are constructed: one of which is based on the concept of high-gain observers, while the other one is consists of a linear Kalman filter gain and the original nonlinear model.

Finally, simulations of motion control to regulate the system to the equilibrium are performed to compare control performances of the output-feedback controllers and results from the different ways of approximation for the flexible cable. Those results show that for each model the high-gain observer approach reveals better performance than the other one. Therefore, we have confirmed that the proposed approach based on the high-gain observer is feasible and effective.