Proceedings of the Fourth (1994) International Offshore and Polar Engineering Conference
Osaka, Japan, April 10-15, 1994

ISBN 1-880653-10-9 (Set); ISBN 1-880653-12-5 (Vol. II)

Dynamic Control of ROVs Making Use of the Neural Network Concept

Tadashi Ooi, Yuki Yoshida, Yoshiaki Takahashi and Hideki Kidoushi
Ishikawajima-Harima Heavy Industries Co., Ltd.
Tokyo, Japan

Abstract

An attempt is made to combine the classical controller with the concept of neural network, the result of which is a control system that we have named the Robust Adaptive Neural-net Controller (RANC). The RANC identifies the dynamic characteristics of the remotely operated vehicle (ROV) including its ambient environment involving cyclic disturbances such as forces induced by waves, and organizes automatically an optimized controller. A tank experiment is described in which the RANC is set to maintain a model ROV at a prescribed depth of water under artificially generated wave disturbance.

Key words: ROV, RANC, Neural Network, Disturbance, PID controller, Jacobian, Oscillator

1. INTRODUCTION

Remotely Operated Vehicles (ROVs) are cable-tethered unmanned submersibles for use in underwater operations and surveys. Remote manual control of these vehicles is an intricate exercise for the operator stationed on the surface tender vessel. To alleviate the burden imposed on the operator, all ROVs are provided with some degree of automation in their control systems.

Such control systems have in the past been based on classical algorithms, which require the parameters of the control system to be adjusted and set beforehand, based on pre-estimated environmental conditions. In practice, however, the underwater environment surrounding an ROV involves factors—such as waves and currents—that are difficult to determine in advance, and this has so far stood in the way of developing an automated control system that would adapt itself automatically to a wide range of underwater conditions.

What was needed was a control system that would automatically adjust its control system parameters so as to match it to whatever environment the ROV would be encountering. The concept of neural network provides precisely such a learning function to adjust the system parameters that determine the manipulated variables, and the present study covers an attempt to apply this neural network concept to ROV control.

In the present study, the neural network concept has been combined with the classical control algorithm, and the result is an ROV control system that we have named "Robust Adaptive Neural-net Controller"—RANC (Kidoushi et al., 1994). The RANC is characterized by the dual constitution of its control system—neural network and PID controller: The neural network serves to formulate the internal models of disturbances, and this facilitates the creation of a robust control system.

The RANC thus represents an advance over the SONCS (Self-Organizing Neural-net Controller System) proposed by Fujii and Ura (1990, 1991), and which pioneered the application of neural network to autonomous underwater vehicles, and was further adapted by Yoshida (1992).

As an example of operation in which an ROV would be engaged, it was envisaged in the present study to have the ROV maintain a prescribed depth under water while being exposed to varying environmental factors—represented in this instance by complex cyclic wave forces. In order to verify the practical performance of such a RANC system, an experiment was performed in a tank provided with wave generating device, by which an ROV equipped with RANC was given the mission envisaged above of maintaining prescribed depth under water subjected to wave force.

2. THEORETICAL CONSIDERATIONS

2.1 Dynamic control system

The control system adopted in the present study is schematized in Fig. 1.

2.1.1 Forward model network

The forward model network modelizes the dynamic characteristics of the ROV in the encountered environment. The network performs the learning function of adjusting its internal parameters in such manner that, upon receiving an input identical to that transmitted to the ROV, it will output signals identical to the ROV response.