Chapter 33
A Mechatronic Description of an Autonomous Underwater Vehicle for Dam Inspection

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ABSTRACT

Driven by the rising demand for underwater operations concerning dam structure monitoring, Hydropower Plant (HPP), reservoir, and lake ecosystem inspection, and mining and oil exploration, underwater robotics applications are increasing rapidly. The increase in exploration, prospecting, monitoring, and security in lakes, rivers, and the sea in commercial applications has led large companies and research centers to invest underwater vehicle development. The purpose of this work is to present the design of an Autonomous Underwater Vehicle (AUV), focusing efforts on dimensioning structural elements and machinery and elaborating the sensory part, which includes navigation sensors and environmental conditions sensors. The integration of these sensors in an intelligent platform provides a satisfactory control of the vehicle, allowing the movement of the submarine on the three spatial axes. Because of the satisfactory fast response of the sensors, one can determine the acceleration and inclination as well as

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the attitude in relation to the trajectory instantaneously taken. This vehicle will be able to monitor the physical integrity of dams, making acquisition and storage of environmental parameters such as temperature, dissolved oxygen, pH, and conductivity, as well as document images of the biota from reservoir lake HPPs, with minimal cost, high availability, and low dependence on a skilled workforce to operate it.

INTRODUCTION

Unmanned Underwater Vehicles (UUVs) are mobile robots used to perform a wide range of activities in aquatic environments and used in some military, industrial (oil exploration and related activities), and scientific areas such as marine biology.

The Remotely Operated Vehicles (ROVs) and Autonomous Underwater Vehicles (AUVs) are the two main subgroups of UUVs (Yuh, 2000). The first is characterized by receiving energy and exchanging information with the control panel on the surface via an umbilical cord. From the control panel, the operator can plan tasks or use a joystick to directly maneuver the vehicle, features which are absent in AUVs as they do not require human intervention during their missions and have no umbilical cord. The power supply is loaded onto the vehicle, as well as the central processing unit. Because they use no cable, autonomous vehicles have greater movement freedom and their use is increasing because of advances in processors and energy storage means, allowing these vehicles greater autonomy.

There are few field studies of underwater robotics in Brazil. Dominguez (1989) realized a study on modeling and developed a program to dynamically simulate underwater vehicles. Cunha (1992) proposed an adaptive control system for tracking trajectories. Hsu et al. (2000) presented a procedure to identify the dynamic model of thrusters. Barros and Soares (1991) presented a proposal for a low cost vehicle that can operate as ROV or AUV. Souza e Maruyama (2012) investigated different control techniques for dynamic positioning.

Worldwide, there is a large number of published works. There are several research areas in the general context of underwater robotics, such as modeling the interaction between fluid and structure (Ridao & Batlle, 2001), modeling of the actuators (Blanke, et al., 1991), control techniques for the vehicle (Antonelli, et al., 1991), simulation environments (Conte & Serrani, 1991), and vehicle design (Miller, 1999).

There are currently 110 hydroelectric plants in Brazil, including small, medium, and large-size installations. Conducting an assessment of the physical condition of each dam is a task that requires time, money, and skilled workers. Considering 74% of Brazil's power is generated by hydroelectric plants, guaranteeing that these reservoirs dams are in good condition ensures the efficient production of energy for the entire population. An inspection task performed by a team of divers can take about a month, depending on the size of the reservoir. With the inclusion of an autonomous underwater vehicle, this task would take considerably less time. The use of an unmanned and autonomous vehicle to maintain dams makes inspection safer and more effective.

Currently, the integrity evaluation of submerged structures is performed with the aid of piezometers, level references, surface landmarks, containment devices, and downstream flow measurements to determine the degree of landfill. Although such devices represent valuable arguments for the maintenance of submerged structures, they do not allow inferences about the existence or characteristics of fractures and the proper localization of them. This assessment procedure is carried out by divers, who face the difficulty of water turbidity, which reduces vis-