A Remote Controlled Vehicle for Interdisciplinary Research and Education

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Abstract

Water quality data collection in shallow water areas can be a challenging task. Obstacles encountered in such environments include difficulty in covering large territories and the presence of inaccessible areas due to a variety of reasons such as a soft bottom or contamination. There is also a high chance of disturbing the test area while placing the sensors. This paper describes a NASA-funded project, which has had a great deal of student involvement and is currently in the test phase, to develop a remote-controlled, shallow-draft vehicle designed as a supplemental tool for our studies of the South Texas Coastal waters. The system transmits environmental data wirelessly via a radio to a docking and control station in real-time.

Introduction

Data collection in shallow water areas normally requires setting up sensors in several places. In addition to being redundant and time consuming, this task when performed manually has a high chance of disturbing the test area. Investigators in the Department of Computing and Mathematical Sciences (CAMS) in conjunction with the Conrad Blucher Institute (CBI) of Texas A&M University-Corpus Christi (A&M-CC) currently collect water quality data in areas with water 3 ft. or deeper by a man-controlled boat. A number of research centers have been developing autonomous boats [1 - 4]. These boats, however, require course planning prior to deployment. As a result, the course is not easily changed once the boat is in the water. This paper describes a project undertaken by an interdisciplinary team of CAMS computer science, engineering technology, geographic information sciences, and mathematics professors and students with environmental investigators at CBI to design and develop a remotely controlled boat that continuously and efficiently collects water quality in shallow water areas (6 in-3 ft), rather than using fixed position sensors to make the water quality collections.

Our boat is small in size (7ft in length and 3 ft in width), has a shallow draft, and can be easily steered to collect data in real-time. The prototype is designed to collect salinity and other environmental data and is to be equipped with onboard computers, water quality instruments (Hydrolab), GPS, digital compass, a remote control receiver, and a receiver/transmitter radio (Freewave). It also has sensors to detect objects from all directions (front, sides, back, and bottom) and will eventually have the ability to intelligently maneuver around obstacles. Acquired data is transmitted wirelessly via a radio to a remote control station in real-time and data is logged to a PC for later processing.

System Design

Designing the boat took into consideration the following operational requirements: (a) The boat was to be remotely controlled within the operator's line of sight, (b) It was to be small and easy to transport in the back of a truck without extra towing equipment, (c) It was to be stable enough to resist waves and wind, (d) It had to have the ability to travel through areas with a draft as small as 6 inches, (e) It had to have sensors to detect objects from all directions (front, sides, back, and bottom), and (f) It had to transmit data wirelessly to a docking and control station in real-time. The following paragraphs describe the major components of the system (see Fig. 1).

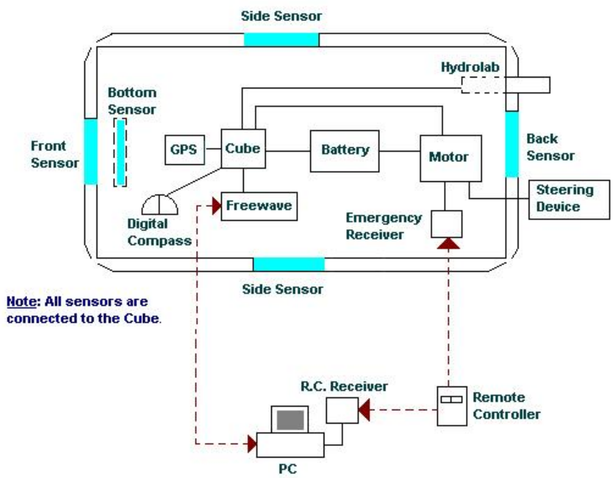

FIG. 1 - OVERALL SYSTEM DIAGRAM

Remote Control Station

This station is located onshore and consists of a remote controller and a PC. The remote controller transmits data to steer the boat and select its speed. The PC is used to store and process the received data and to display the status of major systems and onboard sensors. The PC display serves as a guide to assist the operator with navigation when objects around or under the boat are detected. The operator is able to direct the boat to investigate areas of interest.

Hull Design Issues

Issues considered in selecting a hull shape included onboard weight, type of power, condition of the water in which the boat is used, means of transportation, and the desired draft [5]. Since the draft of the boat is one of the most important criteria, a flat bottom was selected.

After considering a variety of hull materials, it was determined that most materials are too heavy to meet our shallow draft requirement, thus, we selected polyurethane. Polyurethane has two major advantages: (1) It floats with the least draft, and (2) It can be easily modified and customized by carving it before adding a protective coating of fiberglass. The boat deck is carved to fit the battery and electronic components, which are encased in a waterproof container. Total weight of the prototype is approximately 150 lb.

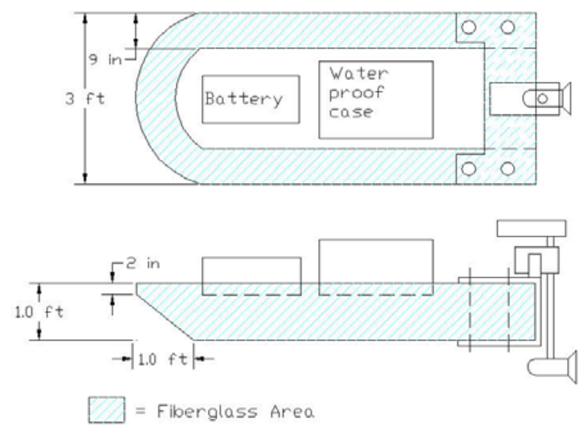

FIGURE 2 – BOAT HULL DIMENSIONS

The transom is strengthened, in order to secure the motor, with 3/16” aluminum sheets. All pieces are configured with reusability in mind and for easy replacement of damaged parts.

Motor and Steering

A MotorGuide model GWT36 electric trolling motor was chosen to propel the prototype boat. This motor is rated for salt water operations and can handle a weight as heavy as 1500 lb. It has hand-controlled steering and 5-speeds forward and 2-speeds reverse.

The motor was easily modified for remote control. The remote control function was accomplished via a Futaba® 6-channel FM radio. Currently only two channels are used. One channel controls the steering via a high torque servo and pushrod that connects to the shaft of the motor and the other channel controls forward and reverse speed via a remote control switch. The control switch consists of two relays that open and close according to the pulse signal of the Receiver (Rx).

This simple configuration worked well for tests of concept in the lab. However, another arrangement was needed prior to sea trials. The original equipment servo harness was made of plastic and could easily break. Additionally, the RC switch did not allow us to control variable speed. It could only provide one speed forward and one speed reverse. The first of these problems was corrected by replacing the servo harness with a 12 VDC steering motor that drives a built-in worm gear in combination with an RC switch to control the direction, left and right. The second problem that of varying the speed of the motor was solved using electronic control, which would allow varying the speed in forward and reverse. The speed of the motor is simply a function of the position of the radio controller joystick [6].

Steering Motor Protection

Since the steering motor is exposed to water, it had to be waterproofed. Two nested boxes are used to keep water from reaching the motor. The outside box prevents splashing water from reaching the motor, and the inside box is an electronic waterproof box that prevents the water that escapes from the first box from reaching the steering motor. The boxes are attached to the transom mount of the trolling motor.

System Power

Two batteries are used to power the system: A marine battery for the motor and another small battery to operate the other onboard electronic components, including; radio, embedded PC, sensors, and GPS. The system operates at medium speed with the 98Ah marine battery for about 4.8 hrs without recharging.

Embedded System PC and Sensors

The onboard PC consists of a stack of PC/104 modules, called the “Cube,” with analog-to-digital conversion capabilities and serial port interfaces. The cube acts as a central control unit and interfaces with the radio and all onboard sensors, including the GPS and digital compass. The water quality sensor is a Hydrolab® designed to be used in fresh, salt, or polluted water. This instrument measures several parameters, including temperature, pH, dissolved O_2, and salinity. Some Hydrolab® models include a pump via a tube to take the water through the process onboard. Such a device is useful in shallow water areas since the Hydrolab® does not have to be immersed in water [7].

Testing the Prototype

Our first “sea test” was performed primarily to determine that the boat draft met the design goal of a six-inch or less draft. We also wanted to gather experimental data to determine the optimal locations of the compartments where the waterproof case and the battery was to be permanently placed. The test was completed on December 17, 2002. The draft was measured at two different places: 1) the bow of the boat and 2) the transom of the boat. The test was conducted first without any load and again with all components expected to be present during an operation (trolling motor, marine battery, and waterproof case filled with the electronic component used for propulsion control and data collection).

The following table summarizes the results.

BOAT CONDITION	DRAFT AT BOW (IN)	DRAFT AT TRANSOM (IN)
EMPTY	1	1.5
LOADED	2	3

The test revealed some major accomplishments: the boat met the draft design-specification and remained stable in rough water conditions with and without the load. Selecting the material used to construct the hull and determining the size of the boat were two important decisions. Increasing the stability of the boat may be achieved by slight modifications of the hull. Stability will also improve when the waterproof case is installed. This will lower the center of gravity and reduces friction from the wind. This may be necessary depending on the strength, durability, and reliability needed during Corpus Christi's windy conditions.

Second Sea Trial

A second sea trial was performed in February 2003. The purpose of this test was to check the steering mechanism and remote controller. Both the steering mechanism and the remote controller met all expectations. We are currently installing the instrumentation and preparing for a third test of the Hydrolab and depth finding systems.

Conclusion

This paper presents the design and development of a remotely-operated shallow-water boat for wireless data logging. The boat was designed to help CBI researchers monitor water quality and pave the way for more sophisticated data collection systems in shallow water areas. The design and development of the boat has had a great deal of student, both graduate and undergraduate, involvement. Initial test results show that the system has the desired features and satisfies the design criteria. This project provides a valuable contribution to research in a number of fields, including oceanography studies, contaminated environments, and hazardous areas.

Acknowledgement

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Biographical Information

Carl Steidley is Professor of Computer Science and Chair of Computing and Mathematical Sciences. His research interests are in the applications of artificial intelligence, real-time computing, and robotics. He has had research appointments at NASA Ames Research Center, Oak Ridge National Laboratories, and Electro Scientific Industries in Portland, Oregon. Steidley received his Ph.D. from the University of Oregon.

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Cody Ross is an undergraduate student in the Control Systems Engineering Technology program at Texas A&M University-Corpus Christi. Mr. Ross has served as both President and Vice-President of the Engineering Technology Society at A&M-CC. He currently works as an Undergraduate Research Assistant.

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