A SHALLOW DRAFT 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 probability 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.

1 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 Center for Coastal Studies (CCS) 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 (Hall, et al, 2002, Ross, 2002, Rocca, 2000, Woods Hole, 2002). These boats, however, require course planning prior to deployment. As a result, the pre-planned 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 along with environmental investigators at CCS 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 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 ata is logged to a PC for later processing.

2 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

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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.

3 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.

4 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 to the launch site, and the desired draft (Handerson, 1972).

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.

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.

The motor was chosen to propel the prototype boat. This motor is rated for salt water operations and can propel a boat 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. Since 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 or 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 (Steidley, 2003).

5 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.

6 MOTOR AND STEERING

A MotorGuide model GWT36 electric trolling presents the most recently collected GPS, Hydrolab, and depth finder information. Additionally, system power constraints in terms of battery voltage and computed estimated running time are displayed on the GUI.

In addition, the depth and GPS navigational data are displayed graphically in a separate window to visually aid the researcher/operator. The GUIs are written in Visual Basic and Gnuplot is used to plot the depth and navigational data in the separate window.

7 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.

8 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. Our Hydrolab® model includes a pump via a tube to take the water through the process onboard. This device is useful in shallow water areas since the Hydrolab® does not have to be immersed in water (Steidley, 2003).

9 SYSTEM SOFTWARE

We have developed our system on a Linux-based platform. The footprint version of Linux runs the Cube PC/104 data collection and control computer. Generally, Linux shell scripts that operate from the Cron utility can be used to execute data collection from a sensor at a specified time or date, once configuration file parameters are set in the shell scripts. However, Cron is limited to execution intervals of a minute or more. Since we require data collection at shorter intervals, we have written a serial task scheduler to collect data. For example, data is collected from the GPS receiver and Hydrolab at 15 second intervals and written directly to compact flash disk memory. The data is wirelessly transmitted by radio from the serial port of the Linux based platform on the boat to the laptop control computer on shore. After error checking the incoming data, the control computer processes the received data for display on a graphical user interface.

To provide the researcher/operator with navigational and current data collection information we have designed the GUI, which.

10 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 were 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 operation (trolling motor, marine battery, and waterproof case filled with the electronic component used for propulsion control and data collection). Table 1 summarizes the results of the draft test.

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. Increased stability of the boat may yet be achieved by slight modifications of the hull. Stability was also improved when the waterproof case was permanently installed. This lowered the center of gravity and reduced friction from the wind. This was necessary due to the strength, durability, and reliability needed in Corpus Christi's windy conditions.

11 SECOND SEA TRIAL

A second sea trial was performed in February 2003. The purpose of this test was to check the

Table 1: First Test Results

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

test results met all expectations. We are currently installing the instrumentation and preparing for a third test of the Hydrolab and depth finding systems.

12 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 CCS 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 of contaminated environments, and hazardous areas.

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