AQUABOT: A High Speed AUV Test Platform

Steven Henderson, Snehesh Shreshta, Joseph Wunderlich

Abstract- Aquabot is a first-generation autonomous underwater vehicle built specifically to test the speed and efficiency of an internally mounted pump jet propulsion system. The platform relies heavily on readily available commercial parts and software to keep costs to an absolute minimum. Driven by a single DC servomotor with a forty percent underdrive belt driven gear reduction the goal is to achieve 10 Knots on no more than three amps of electricity. The 350 lb. vehicle uses a Jet Ski pump driveshaft and seal to maintain watertight integrity to depths of no more than 12 feet. Steering and control is achieved through a continuous software feedback loop between the nozzle control unit and the TCM-2 50 digital compass. The vehicle can be remotely controlled via an onboard Windows 2000 network or through simple simulation programming. The submersible has the ability log all pertinent data to include: speed, depth, motor speed, heading, pitch, and roll. While on the surface this data can be viewed in near real-time or can be downloaded and viewed after the submerged run via the onboard network. Speed and distance is measured using Airmar's CS4500 ultrasonic speed sensor with accuracy to within 0.1 knot and extremely low power consumption. Depth and water temperature is measured with Airmar's smart sensor transducer. These sensors are integrated into the system with a RS-232 interface from the standard NEMA 0183 format. Future plans include optimizing the software control algorithms to this design and eliminating the dependence of a through hull shaft seal to increase the depth rating.

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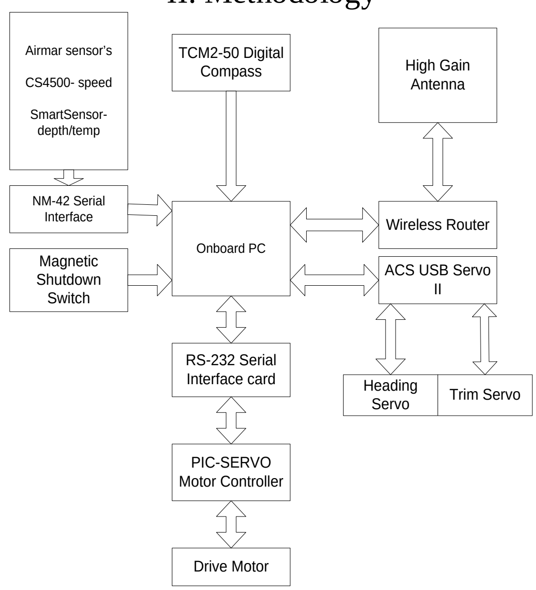
Dr. Joseph Wunderlich is Assistant Professor of Computer Science and Computer Engineering at Elizabethtown College, Elizabethtown, PA 17022. (wunderjt@etown.edu)

S. Henderson, S. Shrestha are undergraduate students at Elizabethtown College.

I. INTRODUCTION

Research in AUV design, current trends and propulsion types has been explored [1],[2]. Aquabot uses an internally housed pump jet propulsion unit with vectored thrust control for steering. The combination of its hydrodynamic torpedo shape along with the absence of any external control surfaces will aid Aquabot in its goal speed of 10 Knots.

II. Methodology



Design and parts selection was based on the COTS (commercial off the shelf) method. Using COTS allows for easier repair and upgradeability of the Aquabot. Parts selection was centered on the ability to use devices that allowed unregulated supply voltages and low power consumption. This eliminated the need for expensive DC-DC converters and simplified the wiring scheme.

The onboard computer is a mini-ITX dual LAN server platform using the VIA C3 E-Series 1.0GHz Processor, Nehemiah core. It has 4 available serial ports, 4 USB ports and two 10/100 Ethernet adapters. It has 1 stick of 256Mb DDR266/PC2100 RAM. A 40GB Western Digital hard drive is installed, and a 54Mb Netgear FWG114P wireless router with an external 8db high gain omni directional antenna using 128-bit WEP encryption enables outdoor communication up to 500 yards unimpeded over a VLAN giving the operator unimpeded control of the desktop via remote software.

The Aquabot's propulsion control system consists of a PIC-SERVO Motion Control Board and a Z232-485 Serial Data Converter from JR KERR Automation Engineering. Using velocity data acquired from the Hewlet Packard quadrature encoder on the servo motor the motion control board can control the output speed of the motor. The motion control board utilizes an LM12801 H-bridge amplifier that has the capability of sensing current throughput for board protection and current limiting. Over current protection happens at approximately 6 Amps while the board maintains no more than 3 Amps continuous.

Steering is accomplished by the ACS USB Servo Control Module and Futaba S5050 Digital Servos that allow PWM feedback for position data. This feedback in combination with the data being acquired by the TCM2-50 Digital Compass can allow differential control of the AUV.

A PNI TCM2-50 three-axis digital compass provides heading with 1.5˚ accuracy (at 0.1˚ resolution), and tilt information with 0.4 ˚ accuracy (at 0.3˚ resolution). Use of the compass will enable the AUV to maintain a steady heading and dive angle using closed loop control with feedback from the digital servos.

An Airmar CS4500 ultrasonic speed sensor that measures vessel speed using echo correlation with accuracy from 0.1– 60 knots, constantly monitors speed. [3]

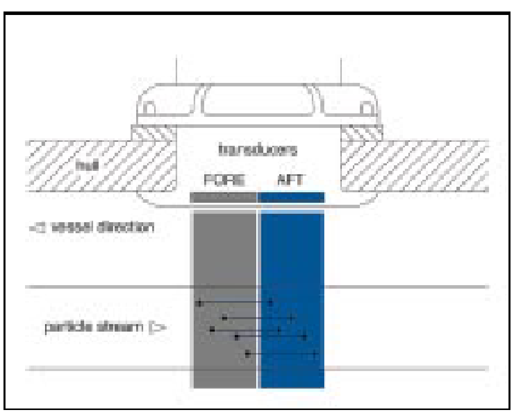
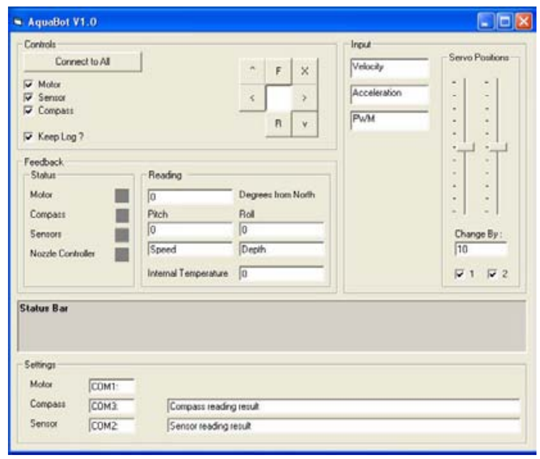


Figure 2. In the CS4500, two transducers are Incorporated in a single housing. Each transducer receives echoes from small random scatterers in the water. For illustration, a group of particles are shown as they would appear in the FORE beam and later in the AFT beam.

Depth to the surface and water temperature is obtained with Airmar's P-17 flush mount smart sensor. The sensor can accurately measure depth within 1.5 ft. It will be used exclusively for closed loop feedback control of depth.

Power is provided to the Aquabot by four 12V 26Amp-hour Hawker Odyssey PC925MJT sealed gel cell batteries for a total of 5 hours continuous running time. They provide up to 400 deep cycle recharges and make up the bulk of the ballast in the AUV.

III. GUI



Since AquaBot is a semi autonomous robot, the GUI has been designed leaving room to implement some sort of autonomy in the future. But the current GUI readily gives you full control over the motor and its speed, steering left and right turns, and also the dive and rise controls. The GUI has one connect button to connect to all devices of the robot i.e. Motor controller, Servo controller, Digital compass, and the Speed and depth sensors. It, however, leaves an option to deselect any of these devices to be connected if needed for testing or error state situations. Everything is logged into a folder called LOG. Files are named by Date and every entry is time stamped. This way in case of errors, it is easy to debug and hunt for error stops. Also the keep board controls for steering and speed control makes it very easy to control. The status bar notifies the user what is going on, what were the last responses from the devices or what went wrong immediately.

References

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[2] Yann G. Le Page," ***Hydrodynamics and Control of an Autonomous Underwater Vehicle equipped with a vectored Thruster",*** Florida Atlantic University, 2000.
[3] Airmar Technology corporation, "*CS4500 ULTRASONIC SPEED SENSOR"*, airmar.com, pdf # 17-1205, 2000.