Underwater Remote Operated Vehicle Redesign and Waterproofing

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Abstract

For my E90 Final Project I intend to redesign and waterproof the Underwater Remotely Operated Vehicle (uROV) built by M. Sepri and S. Brody and improved on by Alexey Rostapshov and Tyler Strombom ’06. The final uROV will be able to be remotely operated from a laptop computer to the depth of 12 ft. The uROV will also be able to compensate for current and drift, as well as retrieve objects and perform simple tasks from preprogrammed instructions. The project will be supervised by Carr Everbach.

Introduction

Alums Alexey Rostapshov and Tyler Strombom ’06 built and tested the current uROV. However, during the testing process, an unforeseen problem with the circuit boards, most likely resulting from a less than optimal design, resulted in the robot failing before it could be tested in the Ware Pool.

The current design challenge lies not in the selection of the parts, many of which have already been purchased and used previously, but in the reapplication of these parts to form a less complex operating system, which can be more tightly waterproofed. To this end, the current goal is to redesign, rather than wholly rebuild, the current uROV. Unfortunately, watertight couplers for the wiring, while available, are very expensive. If work proceeds quickly, I hope to bring the robot to a level necessary to compete in the Autonomous Underwater Vehicle Competition.[1] The primary challenges will stem from the need to fully waterproof the uROV while simultaneously reducing its weight. Also, the full integration of the component electrical systems will require the rebuilding of the uROV’s CPU and the creation of a new set of programs to drive the machine. Preliminary testing as disassembly of the uROV, it was noted that several of the circuit boards previously in use had sparked and charred, rendering them useless. They will have to be rebuilt after the initial cause of failure is isolated and accounted for in the new design. It is important to note that all of the pumps designed to drive the robot are currently functional, and several of the batteries still hold charge, reducing the startup cost.

Finally, it is possible that, after I perform a full inspection of the old uROV and determine the necessary redesign work, I will want to instead build a new uROV. However, in this case, Professor Everbach has already expressed his willingness to let me cannibalize the current UROV for a new one provided that the plans are reasonable. Therefore, while more materials would need to be bought, most of the expensive electronics would be reused, bringing down costs.

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[1] <http://www.auvsi.org/competitions/water.cfm>

This report continues with a technical discussion of the project and the uROV's system and components. It will continue with a brief outline of the current project tasks, which will then be organized into a timeline using the Critical Path Method. Finally, the report will conclude with a section describing the qualifications I bring to this project and the projected budget for the project.

Technical Discussion

The current Underwater Remotely Operated Vehicle (uROV) will draw strongly on the previous work done by Alexey Rostapshov and Tyler Strombom '06. To this end, the current design for the robot envisions the same macro-structure as the previous uROV, and the modular design envisioned by Rostapshov and Strombom is presented below.

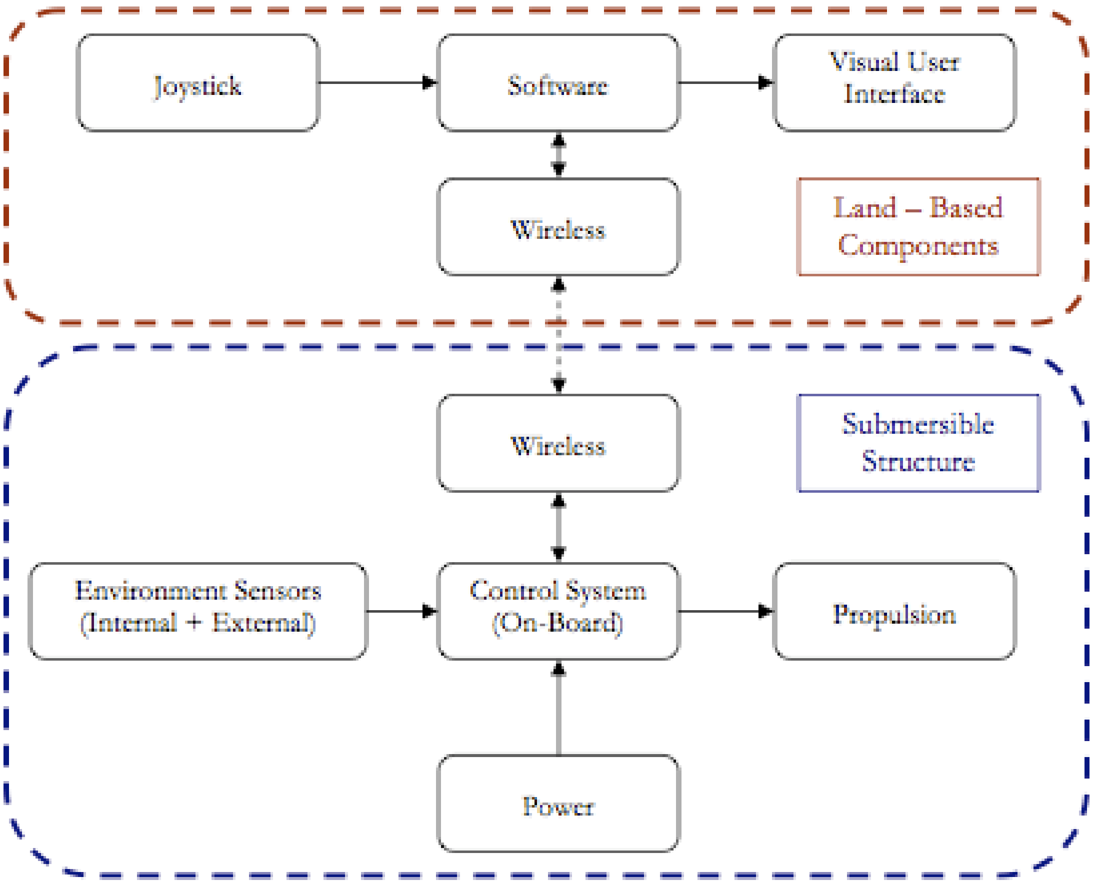

Figure 1: Modular View of the uROV systems[2]

Sensors

First, I will discuss the environmental sensors. The current uROV has a variety of sensors, which fall into two groups: positional sensors and internal (damage control) sensors. The former serve to locate the current position and movement of the uROV and are measured by four components. Because of the nature of the sensors, the operating environment, and the desire to be able to operate the device far away from its actual

[2] Rostapshov, Alexey and Tyler Strombom. "Design and Implementation of an Underwater Remotely Operated Vehicle (uROV)." 30 Nov 2005.

position, a number of redundancies were built into the system. The first component is an Analog Devices ADSRS401 iMems gyroscope, which will be used to determine the pitch and roll of the uROV. The purpose of this system it to keep the robot oriented vertically, so that the relative positions of all its components to the surroundings are known and so that any propulsion results in movement in the proper direction. The second component is a Devantech CMPS03 magnetic compass module that uses a pair of magnetic field sensors mounted at right angles to compute the direction of Earth's magnetic field. This system orients the uROV in the horizontal plane. However, because of the necessity for redundancy, a second gyroscope was also added to give a measure of relative yaw in order to allow the robot to function without the compass. By marking the initial posistion, the uROV should be able to output enough data to give an inertial log that will allow us to return the robot to its original position without the use of the compass. Third, is the pressure transducer, for which a Measurement Specialties MSP is used. The water pressure on the side(s) of the uROV can be translated into depth readings. The final component is a series of three accelerometers mounted perpendicular to one another. These, combined with the pressure sensor and the back-up gyroscope should be sufficient to fully locate the uROV in the water.

However, because of the extreme delicacy of the electronic componenets of the uROV, leaks are of a major concern. Therefore, a number of leak sensors are also mounted on the uROV, consisting of two parallel lines drawn with a conductive pen, and connected by a voltage source. A leak will short-circuit the lines. Finally, both gyroscopes has an intrinsic temperature sensor for calibration, witch will be used to detect overheating.

Control System

The design for the control system for the uROV remains of the utmost importance. The current design utilizes a OOPic "S" Board microcontroller. This is because of the ease with which it can be integrated with Inter-Integrated Circuit (I^2C) compliant devices, including the Devantech compass. Furthermore, the WMC controller used in the uROV is specifically designed for compatibility with the OOPic. The OOPic will be programmed to perform simple station-keeping maneuvers and to initiate emergency surfacing when conditions warrant (including leak detection, battery failure, etc.).

Communications

Two Wireless Communications Module (WCM) Transceivers are being used to connect the uROV to its oprating computer. Currently, because the the WCMs use RF signals which do not propagate through water, requiring the uses of a buoy for the antenna, this project will include a search for a better wireless communication method.

Propulsion

The uROV is currently moved by four propellers driven by a pair of bilge pumps from Sepri and Brody's original Underwater Vehicle and have since been greatly updated to increase thrust. The current fans are scavenged from a computer case and allow flexibility in rotational speed. There are an additional four propellers mounted vertically.

Power

The power source for the uROV consists of 2 12 vold, 12 amp-hour batteries for propulsion and a Lithium-Polymer 7.4V, 1.5 amp-hour pack to supply the controller. The current power allotment for the bilge pumps will need to be redesigned and will depend partially on the effectiveness of the waterproofing.

Project Plan

The following table summarizes the anticipated activities and the limits and feeds from and to other activities, as well as their expected duration.

Activity	Needs	Feeds	Duration (d)	Effort (h)	Action
A	-	C	4	8	Evaluate the current uROV, specifically the state of its electronics
B	-	D,E			Research Waterproofing Options (waterproof connectors, waterproof containers, sealants, etc.)
C	A	D, E	3	6	Perform additional research regarding the electronics
D	B	D	7	5	Choose and purchase parts
E	B, D	G,K	7	14	Redesign current uROV configuration (esp. wiring)
F	D	G	7	14	Individually test all Sensors
G	E	L	30	60	Program PIC microcontroller
H	E	L	30	60	Create/Update PC Software
I	-	J	7	14	Research Wireless System Options
J	H,I	K	5	15	Implement Wireless
K	J	L	15	30	Physically Build System
L	G, H, K	M	10	20	Integrate all Systems and Waterproof
M	L	N	7	14	Test in Ware Pool
N	M	-	14	7	Write Presentation and Report
Total			146	260	

Project Qualifications

Jonathan Shoop is a senior engineering student. He has basic knowledge of Matlab and C/C++. He also has general experience in the shop, specifically with the lathe, Bridgeport, drill press, saws, and other tools. Furthermore, he will be taking Robotics next spring in order to widen his knowledge of programming and design.

Project Costs

The total project cost is at this time not calculated. A thorough review of the Underwater Remotely Operated Vehicle is needed before statements can be made as to the status of the current sensors, as well as the need for additional sensors. However, because the project intends to primarily use preexisting parts, the total cost should be low.