Autonomous Kayak with Water Sampling Capabilities

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Abstract

Dr. Anthony Choi asked that the autonomous kayak project from last year be redesigned. Santa Clara University requested the original design. The goal of last year's project was to upgrade the electrical components of the kayak in such a way that they would fit into the structure of Santa Clara's existing kayak fleet. Michael Deakin, Sara DeWitt, and Josh Phillips designed the original kayak for Santa Clara. All of the electrical components of their design were delivered to Santa Clara.

The Design from 2013 was subject to several limiting specifications that were laid out by Santa Clara University, mostly adhering to the existing communication standards setup by Santa Clara University. All of Santa Clara's original specifications have been removed from the design, and Dr. Anthony Choi has added his own specifications and requirements.

Dr. Anthony Choi has requested several specific specifications and improvements to last year's design. The previous design used a long range modem to transmit data which was limited by a low data rate. Dr. Anthony Choi has requested that a short range omnidirectional high data rate modem be added to the Kayak that can later be connected to a 4G capable device for long range communications. Additionally, he has requested for an updated and more robust electrical system. He has requested that a water sampling device be added to the kayak, and that it be capable of providing Ethernet connection and power to an autonomous submarine.

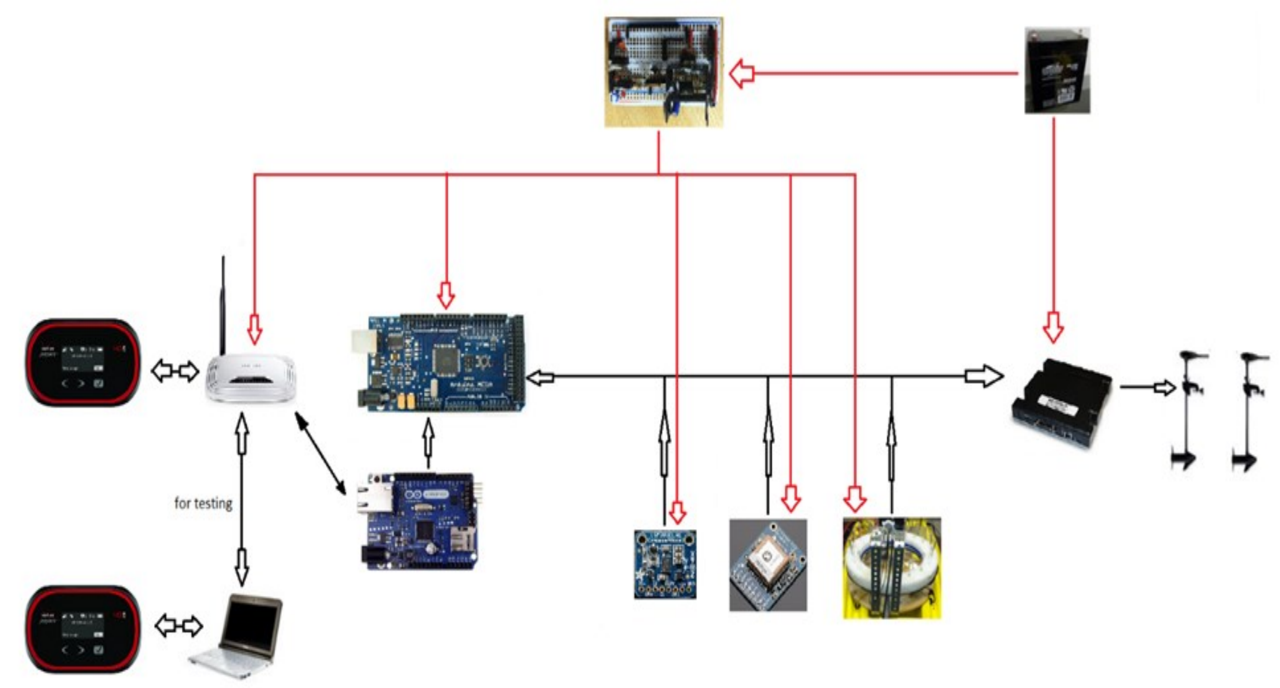
Introduction

Autonomous systems development is a rapidly increasing filed of engineering. The goals of this project were to improve the electrical system, and add water testing capabilities to the autonomous kayak. After the original design of the autonomous kayak, most of the electrical components were returned to Santa Clara University. This year's team was tasked with improving the electrical components of the system, upgrading the software, and adding a water sampling equipment.

The team also wished to improve the speed of the kayak and reduce the overall amount of electrical equipment on the kayak. The software improvements were meant to include autonomous waypoint navigation for the kayak, as well as retaining the ability to control the kayak as a remote controlled device. Lastly, the kayak has to provide Ethernet and power to an autonomous submarine. The team wished to integrate these changes into the existing design, without adding complexity.

Electronics System

The electronics system is loosely based on the framework of last year's system. The compass, GPS, and motor controller were replaced with better models. The modems were replaced with a router that can support 4G a hotspot. The power board was updated to support the water testing equipment as well as modified to provide power to all the electrical components. Figure # shows the framework of the system and shows how each component communicates with each other. The electronics system was designed to support future implementations.



Software

The software on the kayak is designed to be used over a LAN communications network. A connection is established with the kayak and keyboard commands are sent to control it.

The kayak has two software modes. The first is a remote controlled mode. This mode was improved from the previous design and allows the kayak to be controlled like an RC car.

The second mode is an autonomous mode. In this mode, the kayak is given a series of waypoints that it can navigate to. A heading pointing algorithm is used to steer the kayak towards its waypoints.

RC Commands:

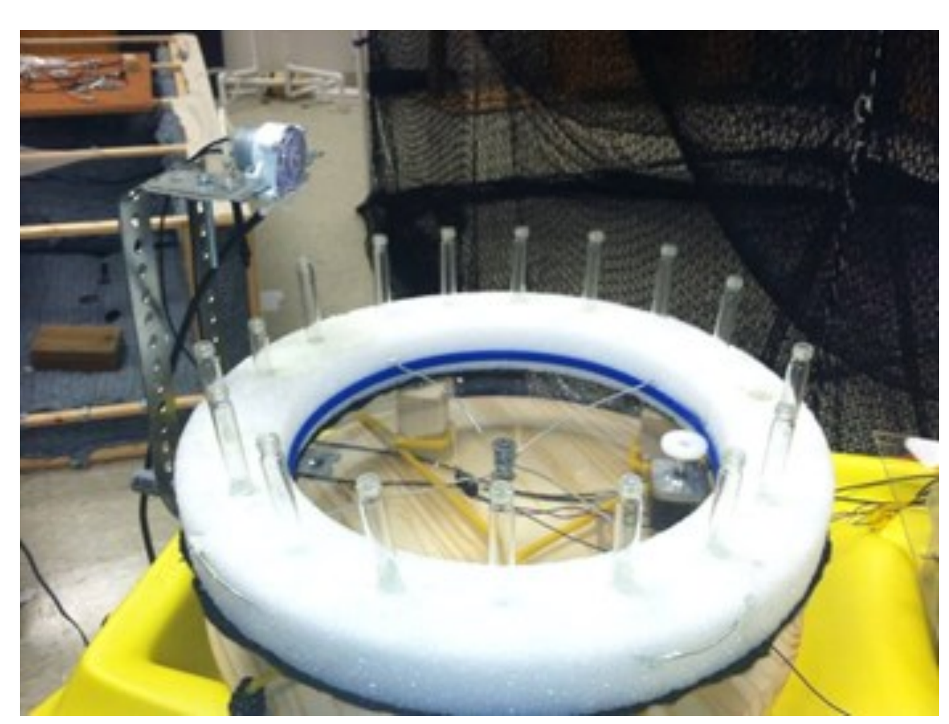
Command	Effect
'f'	Turns the left and right motor to 1900. Kayak moves forward.
'r'	Turns the left and right motor to 1200. Kayak moves in reverse.
's'	Turns the left and right motor to 1500. Kayak stops.
'q'	Turns the left motor to 1700 and the right motor to 1800. Kayak moves forward with left bias.
'e'	Turns the left motor to 1800 and the right motor to 1700. Kayak moves forward with right bias.
'p'	The motors stop and the kayak takes a water sample.
'l'	The server prints the kayak's current GPS location to the base station.
'h'	The server prints the kayak's current compass heading to the base station.
'x'	The kayak exits the remote controlled mode.

Autonomous Commands:

Command	Effect
'w'	Add a waypoint to the kayak.
'r'	Add a return waypoint to the kayak.
'e'	Executes the autonomous navigation with the specified waypoints.
'x'	The kayak exits the autonomous mode and returns it to the home waypoint. This can only be issued before the 'execute.'

Water Sampler

The water sampler design is similar to the design of a rotary phone. Once the system receives a signal to take a sample the peristaltic pump will drain for one minute. This will clear the old water from the hoses. Then the pump will stop and the stepper motor will rotate an empty sample vial into position. The pump will run for fifteen seconds filling the empty vial with water. Then the stepper motor will rotate back to the drain hole and wait for the next signal to take a sample. Figure 1 shows the completed water sampler.



Conclusions

The electrical system meets the design criteria. It passed all the tests that proved the electronics system is working. All the components integrated well and the system as a whole is functional.

The water sampler meets the goals of the design. It passed all of the mechanical tests. Although no chemical analysis was done on the water samples, the team expects that sample transportation will be more influential on the samples than the collection procedure. This system is not designed to store samples for a long period of time.

The remote control portion of the software meets and exceeds the capabilities of the previous kayak design. The autonomous portion adds entirely new capabilities to the kayak. Overall, the software changes were a major success.

Recommendations

The housing for the electrical components need to be improved. Waterproofing and stability are the main issues. These can be resolved by purchasing a weatherproof case and designing it to fit the electrical components. In order to maintain sample integrity some changes need to be made to the water sampler. For biologically active materials, samples should be stored in a cold dark location. Cooling and shading the samples would improve the system.

The autonomous portion of the software needs to be improved. Additionally, a new mounting system for the compass module would improve performance of the heading algorithm. Additionally, the software can be improved by adding various reconnect features and fail safes to ensure the kayak can safely be retrieved.

Acknowledgements

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