University of Colorado Boulder

RoboSub Team

Water Buffalo

Pierson Connors
Nathan Bellowe
Rod Jafari, Sea Harrison, Kyle Harlow, Alex Silverman

Team Introduction:

Our team is comprised of six Freshman and Sophomore physics and engineering students from the University of Colorado Boulder. The team started in December 2013 breaking away from the main Boulder Robotics Club, who wanted to focus on hobby robotics. Early April the team received a $1500 grant from CU Boulder's Engineering Excellence Fund. Since the beginning of summer the team has been working out of both California and Colorado adding another layer of complication to the already challenging road to RoboSub. Because of the vast challenges of the competition and the short amount of time the team has been together we have a simple goal for RoboSub 2014, pass through the Gate.

Design Principles:

Due to budgeting and time constraints many of the more professional and typical robosub solutions were not available to us. Off the shelf solutions needed to be used whenever possible. Inspiration was taken from older RoboSub journal papers, as well as an organization called Open Source ROV. Open Source ROV is a bay area group that developed a completely open source kit to build your own remote operated submarine for less than $1000.

Hull:

The hull was inspired by the numerous teams who have used Pelican Cases in years past, such as the Naval Academy, University of Utah and San Diego City Robotics. The Pelican Case is an off the shelf waterproof plastic case. Many Teams in RoboSub use a plastic or metal tube with metal end caps to house their electronics. This solution is preferable to the for a number of reasons but has two fatal flaws for our team. First is cost, the raw material cost of the tube and aluminum end caps, which for our application would have been in excess of $300. In addition to that waterproof connectors to send power to the motor cost between $20 and $50 each. This brings a total price to in the range of $500; Much higher than the $60 for a Pelican Case. The second fatal flaw is the manufacturing time. Endcaps would need to be custom machined from metal stock to work, which could have taken months. Therefore the Pelican Case was Water Buffalo's best option. Connections to the thrusters is done by drilling a hole for each wire to pass through and sealing the wire in place with epoxy and Sugru. A waterproof wiring solution that has been thoroughly competition tested.

Thrusters:

Thrusters were the largest challenge in the hardware design. Off the shelf solutions include ROV thrusters, such as those Seabotix and VideoRay, which cost hundreds of dollars each. Researching this challenge we came across

Open Source ROV, which had encountered a similar problem. They found that with small modification to the wiring Hobbyking 2213N 800Kv Brushless motors could work under water. Combined with Graupner 3 Blade 65mm propellers they could generate over a kilogram of thrust. Water Buffalo is outfitted with 8 of these Motor propeller combos in custom made polycarbonate shrouds.

Electronics:

The electronics team is in charge of designing and maintaining all of the electrical systems within the submarine. This includes supplying power to the computer systems, motors, and sensors, along with wiring the various digital and analog systems on-board. The electrical team had the least work compared to the Mechanical and Software teams, and was therefore merged with the software team for the majority of the time. This allowed for increased productivity and better communications. Therefore, isolating specific electrical team tasks, outside of power management, becomes difficult due to this collaboration.

Sensors:

Water Buffalo uses 2 Inertial Measurement Units (IMU) each wtih three axial gyrscopes, accelerometers, and compases. The first which has a built in pressure sensor is a custom sensor board by Open Source ROV which is mounted outside the hull. Just inside the hull next to the Open Source ROV IMU a SparkFun Razor 9 Degree of Freedom IMU is mounted. Mounting these sensors as close as possible makes it simpler to compare the data.

Microprocessor:

Water Buffalo is run by a Beagle Bone Black(BBB). The BBB can send PWM signals to our electronic speed controllers and process the signals from our IMU’s It also can run off USB power which simplifies the power system design process.

Power:

5 different batteries are used to power Water Buffalo. Four 11.1 volt 4000mAh are run in parallel to power the thrusters. A portable mobile device charger is used to power the BBB.

Software:

Water Buffalo runs off of Angstrom, a version of Linux specifically created for embedded applications. This allows for higher level languages than many embedded systems, and allows expansion to more third-party applications,

such as OpenCV for image processing. Additionally, it allows for the use of the Robot Operating System. This provides us with a number of useful tools and libraries built in.

Currently our major goal is to pass through the validation gate, and this allows our software is relatively simple. Water Buffalo takes in Gyroscope and Accelerometer data from the two IMUs and uses that data to determine its orientation and heading. Compases or magnitomiters are not used because of the massive EMF interference from the motors, as well as magnetic fields given off by the competition pool walls. Water Buffalo also takes in pressure sensor data to determine its current depth. With the current heading depth and orientation of Water Buffalo the BBB uses pid algorithms to maintain a fixed heading and depth, until the diver switches the kill switch.

Acknowledgements:

The University of Colorado Boulder would like to thank the following people and groups for their assistance with competing this year:

Dr. Nikolaus Correll - Team Advisor
Open Source ROV - Useful information and solutions
Engineering Excellence Fund - $1500 in grant funding
Kevin Chen - Electronics advice
Eric & Lara Connors - Logistics support
Boulder Robotics Club - Initial support
Bobbie Lee Atkinson - Grant Administration, Procurement assistance