Robosub 2014

California State Polytechnic University, Pomona

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Abstract

Robosub is an annual, international competition sponsored by the Office of Naval Research (ONR) and the Association for Unmanned Vehicle Systems International (AUVSI) designed to challenge teams in building a Autonomous Underwater Vehicle (AUV) to meet the competition requirements. This competition is held this year at SSC Pacific TRANSDEC in San Diego, California from July 28th through August 3rd.

We (the CPP Robosub team) are the pioneer team from California State Polytechnic University, Pomona (henceforth Cal Poly Pomona). Our primary goal is to compete in the 2014 Robosub competition with a limited budget of $3,500. The equipment and methodology discussed in this paper reflect our diligence and ingenuity in meeting the competition requirements and our budget goal.

Team Purpose

We are a team composed of electrical and mechanical engineering students, with some experience and interest in robotics. We entered the Robosub competition to challenge our understanding of robotics and to gain experience above and beyond what we have learned in classes and labs. As Cal Poly Pomona's pioneer team, our aim is to leave this project as a foundation for a new team to compete the following year. The next team will have full access to our hardware, software, as well as all the relevant documentation to refine and improve on the our original design.

Design Strategy

We've broken the competition events down into the following high-level vehicle requirements:

Color and object recognition

Holonomic movement

Localization

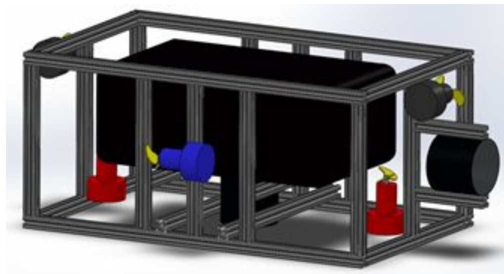
Three dimensional velocity control

The following sectional design discussions are directly influenced by these requirements.

Vehicle Design Specifications

Mechanical

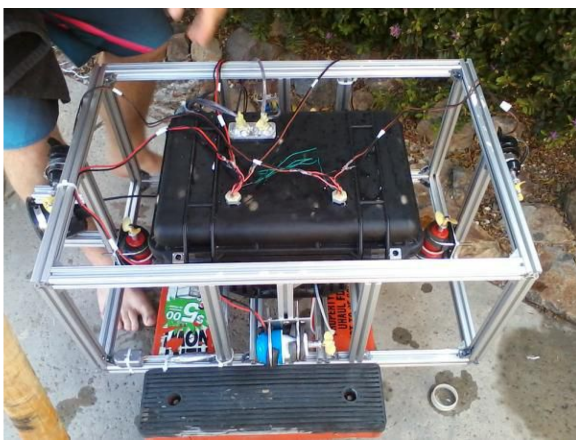
Frame



The frame design focused on rigidity and weight. A rigid frame protects all the electronic and electromechanical equipment from damage incurred through collision. A light weight frame allows for greater maneuverability in the water and the use of smaller, less expensive thrusters. Thus the frame is constructed from a light weight, high strength T-slotted aluminum square frame.

All equipment is attached to the frame via the T-slots by screws and specialized sliding bolts allowing for convenient modification through modularity. This has allowed for cost-free design changes. SolidWorks modeling was used to conduct software tests for center of mass and pressure.

Waterproofing



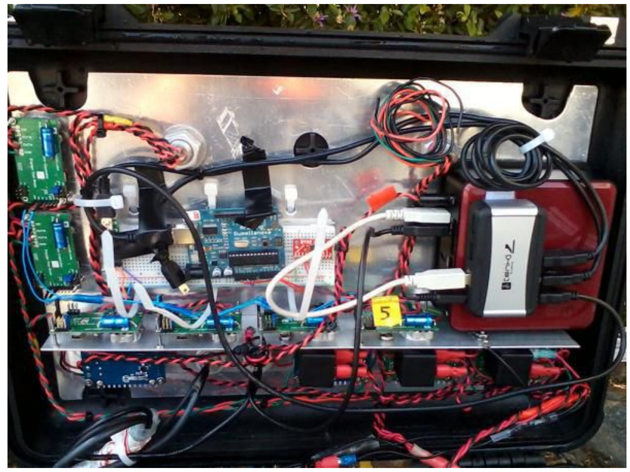
In order to reduce the number of holes in our pressure vessel, we elected to drill holes in the aluminum bolts used for heat syncing to transfer power and communication. Ensuring water tight transfer of power and communication from inside the pressure vessel to the motors and sensors was problematic; merely sealing around the jacket of the wires was not good enough, because if the jacket of the wire gets a crack in it, the water will migrate between the wire and jacket causing a leak. To solve this problem, we stripped a small section of every wire, put silicone and heat shrink around it. Then we used a two part epoxy to seal that section of wire inside the aluminum bolts.

Electrical

Hardware

Power

The system contains 3.3V, 5V, 12V, and 19V power supplies. These are obtained through the use of separate voltage regulators attached to a 24V battery. The regulators supplying the motor controllers are toggled using relays in order to allow the motors to be switched off without shutting down the Intel Next Unit Computing Core i3 (henceforth the NUC), our onboard computer.

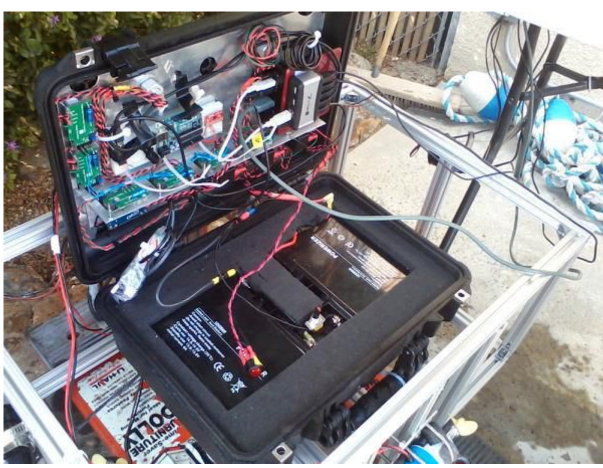


Sensors and Processing

The IMU (Inertial Measurement Unit) and pressure sensor are preprocessed using an Arduino Nano which communicates serially with the NUC, providing linear acceleration, rotational velocity, and three dimensional heading, and water pressure. Two Logitech USB webcams are connected directly to the NUC.Converted Bilge Pumps were used as thrusters due to their cost and power efficiency.

The NUC is the ideal choice for a small, low cost platform. Its form factor is very small, and fits in almost any orientation. The processor architecture is x86, which means that a majority of the required software is already compiled for our platform. Also, because the NUC requires a solid state drive for storage, the platform is inherently fast and vibration tolerant.

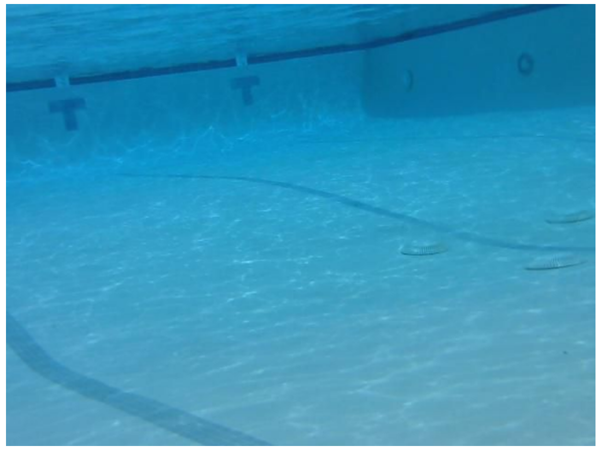
Cooling



Within an air tight capsule, air cooling components is not an option. We needed to be able to transfer the heat generated by the components to the body of water without creating leaks. We mounted the components to an aluminum plate inside the pressure vessel and used large aluminum bolts going through the wall of the pressure vessel to transfer the heat to the water. O-rings were used to seal around the bolt heads.

Software

Environment



The software is built on an x86 environment running the Linux distribution Ubuntu 12.04. We used Python with SimpleCV because it was both powerful and simple to use. The entire project uses custom python modules to make a simple API.

All the external I/O to the vehicle is done over 115200 baud serial lines. When the software boots it goes through a initialization process that checks that the motor controllers are connected, and then tells the motor controllers to listen, and takes them out of a safe start mode. A similar process takes place for the IMU.

In case anything goes wrong, the software is designed so that everything is logged, including any exceptions that occur. The real-time logging includes the motor and sensor values being passed as well as what function was running. It also can record video and take pictures from the onboard camera useful in vision code debugging.

Control

The vehicle is controlled by a combination of PID loops and fuzzy logic control loops. The sensor feedback from the IMU, camera, and pressure sensor is fused within the fuzzy logic controller and decisions are made based on *a priori* event knowledge and the sensory inputs. The vehicle is able to focus on an objective and to navigate to and interact with the objective as long as it remains in focus.

For example, the starter gate is made up of two orange poles 5 foot long and 3 inches in diameter. They are spaced 10 feet apart, and they are floating vertically in the pool. In order to qualify, teams must be able to go through this gate.

In order to be able to identify the gate, the software will process the images so that only a small range of orange colors are left in the image. Then it will identify the largest clusters of orange (because those blobs will be the poles of the gate) and then calculate the central point of those clusters. This allows the vehicle to know where the center of the gate is, and then to drive through we simply turn the vehicle until the center of the camera is aligned with the center of the gate, and drive forward. We can use the IMU to estimate how far the vehicle has traveled once the poles of the gate are no longer in view.

Next Steps

Our aim is to place with or above other first year teams in the competition this year, and to leave a foundation for future participation by Cal Poly Pomona Robosub teams.