Deep Flight: Unmanned Underwater Robot V3

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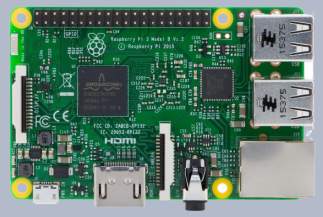
Motivation

The Robotarium Research Lab at the University of Calgary has been developing an HMAUV since 2014. There have been three hardware vehicle prototypes, each enhancing the previous design.

The goal of this project is to aid in developing a highly maneuverable autonomous underwater vehicle (HMAUV) to enable safe and autonomous navigation in highly obstructed GPS-denied environments, such as coral reefs or oil and gas underwater infrastructure. The team is developing enhanced versions of the electronic and software systems to reduce cost, improve system integration, and create a user-friendly design so that other users can test the development of such vehicles. The vehicle is operated by three thrusters, providing movement in six dimensions (roll, pitch, yaw, lateral, vertical, and horizontal).

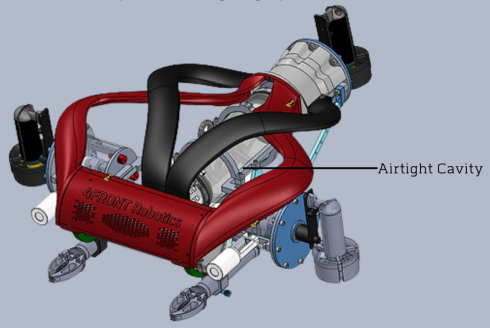
The Problem

The Robotarium Research Lab designed this HMAUV to be capable of deploying and navigating within underwater confined spaces (e.g., oil and gas underwater infrastructure, coral reefs, etc.). The main objective of the current design was to be more cost-effective and extensible compared to traditional underwater vehicles.

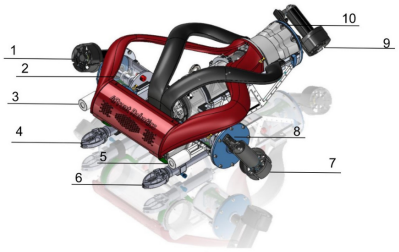


Our Solution

Our solution combines software and electrical systems contained within an air-tight cavity to control the HMAUV. The electrical system consists of a Pixhawk Autopilot system and a Raspberry Pi, allowing for the integration of COTS (commercial of-the-shelf) components, robotic elements, and power management. The software component has two functions: providing control inputs for the thrusters through pre-programmed commands or manual inputs, and providing critical information to the operator through a graphical user interface.



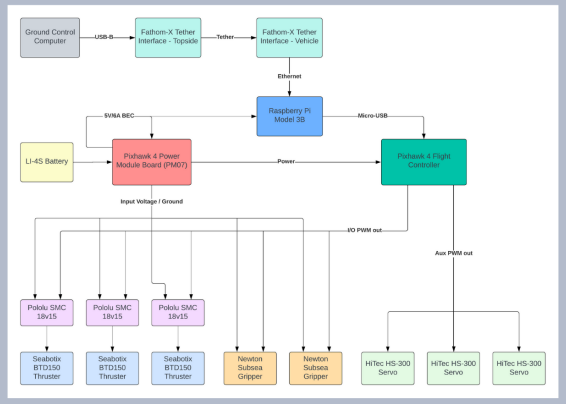
The Vehicle



1	Right Thruster	6	Left Gripper Arm
2	Right Thruster Servo Motor	7	Left Thruster
3	Right Camera	8	Left Truster Servo Motor
4	Right Gripper Arm	9	Rear Thruster
5	Left Camera	10	Rear Thruster Servo Motor

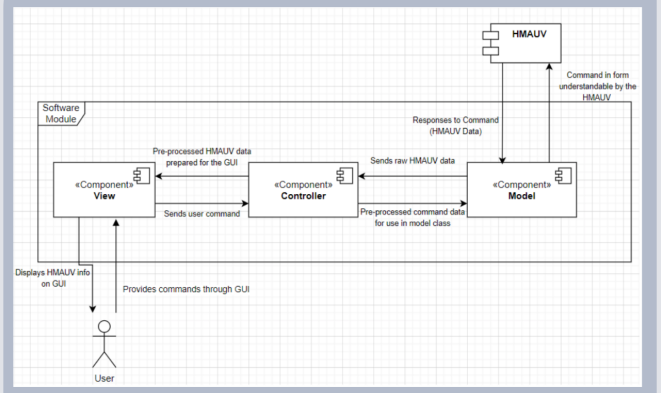
The vehicle has three thrusters (located at 1, 7, and 9) that can tilt and operate at different angles. The combined thrust provides 6 degrees of motion: roll, pitch, yaw, lateral, vertical, and horizontal). Our team is responsible for controlling the individual thruster power and thruster angle. In the final implementation of the vehicle, the HMAUV will also have grippers (located at 4 and 6) and cameras (located at 3 and 5).

Hardware System Architecture



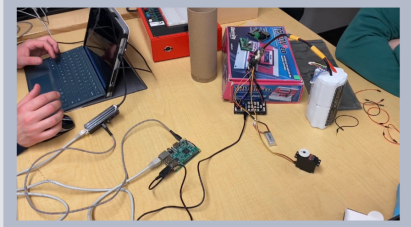
The communication link between the ground hardware system and the onboard hardware system is the Fathom-X Tether Interface, in which the Raspberry Pi 3B will receive high-level commands via the ground control computer. The Pi will then send these commands to the Pixhawk 4 Advanced Flight Controller to manage and control each thruster, ESC, servo, and gripper. The lithium-ion 4S battery will be connected to the HolyBro PM07-V21 board, which will distribute the power from the battery to all onboard devices.

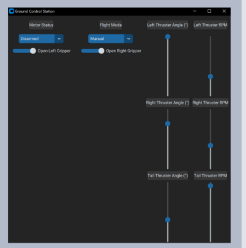
Software System Architecture



Model: contains logic, calculations, and direct command communication with the HMAUV
View: user interface to display data and receive commands from the user
Controller: processes command data and relays such data between Model and View
HMAUV: Raspberry Pi communicates high-level data with Model and communicates converted low level data with Pixhawk 4

Current Progress





Our team has successfully established a communication pipeline between the ground control computer and the onboard hardware. Using the software system, we are able to send commands to the servo motors and robot arms. The software team has also developed the framework for the GUI (graphical user interface), which will be used to control the angle and force of the thrusters, as well as display critical information to the operator such as position, runtime, and other relevant data.

Future Work

There are several enhancements that can be considered for future iterations of the current design, such as a rechargeable battery without the necessity of opening the HMAUV cavity, implementing a terrain warning system and cameras, implementing a joystick controller, and updating the GUI to contain additional functionalities and display more information.