Biomimetic Autonomous Underwater Vehicle

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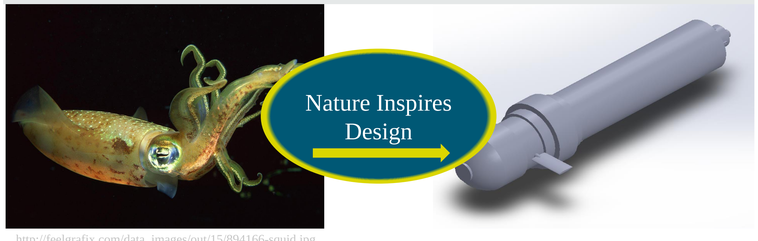
Abstract

The goal of this project was to design an autonomous underwater vehicle (AUV) that takes inspiration from nature, specifically cephalopods., This AUV mimics the propulsion and motion of squid using a vectored water jet propulsion system, as well as forward diving planes. The biomimetic AUV is capable of autonomous motion in an aquatic environment, including self-stabilization and obstacle avoidance. This is accomplished through underwater ultrasonic sensors and a 9-axis inertial measurement unit, Additionally, this device includes the capability to monitor water temperature and record data for future analysis. The key design components of this project are: a waterproof and neutrally buoyant hull, the use of a Raspberry Pi microcontroller to program the AUV using the Python programming language, a water jet propulsion system that allows the thrust to be vectored by 15 degrees, and a navigation system that includes a sonar sensor and an inertial measurement unit. Results, so far, are that the AUV is capable of motion and self-stabilization in an aquatic environment, and is also able to react to and avoid objects in its forward field-of-view. Additionally, the biomimetic AUV is capable of monitoring its depth and record water temperature data. In its current state, the biomimetic AUV could serve as a platform for additional water-sampling equipment as well, such as the monitoring of pH.

Problem Definition

The goal of this project is to develop a device which utilizes biomimicry and monitors a marine environment autonomously



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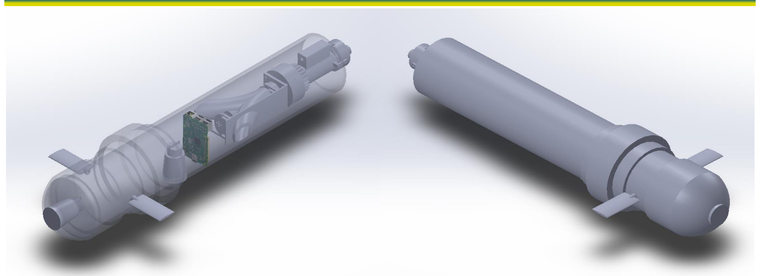
Design Requirements

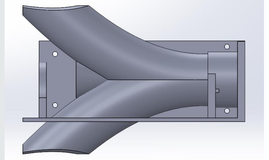
Biomimetic Propulsion	Take inspiration from biology in the development of the propulsion system
Autonomous Navigation	The ability to navigate and avoid obstacles in its environment without assistance
Water sampling	The ability to extract water temperature data autonomously

Overall Design



Propulsion System

The biomimetic AUV is propelled with a unique vectored thrust dual-intake water jet. Utilizing a brushless DC motor, as well as stepper motors to control rotation, thrust may be vectored to 15˚ in any direction. To assist with maneuverability, two independently-controlled diving planes are located toward the front of the AUV. These provide stability and allow for control of roll and pitch.

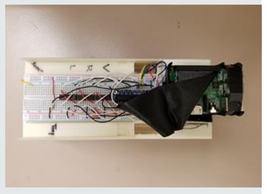


Navigation System

A combination of ultrasonic sonar sensors and an inertial measurement unit (IMU) allow the AUV to navigate. The MaxBotix MB7072 ultrasonic sensor used in this device has a maximum range of over 7.5 meters, with a resolution of 1 centimeter, and allows for obstacle detection. The InvenSense MPU-9250 9-axis IMU uses the combination of a magnetometer, gyroscope, and accelerometer to measure position, angular velocity, and angular acceleration to ensure that the AUV is oriented correctly.

Software

The biomimetic autonomous underwater vehicle utilizes as Raspberry Pi Model 3 B, using the Raspbian operator system, as the primary microcontroller. The software to run the device was written in Python3, and employed the Geany development environment. The Raspberry Pi was selected for its price, ease of use, and access to communication protocols such as I2C.



Results

The biomimetic AUV is currently capable of autonomous motion and obstacle avoidance through the use of its vectored thrust system and sonar sensor. In addition, the AUV is able to recognize and stabilize against changes in tilt and roll through the use of the inertial measurement unit. Although core functionality is present, both reaction speed to objects and roll accuracy are not optimized, and the system might be improved through the use of a more advanced motor control system. Along with this, water temperature sampling is functional; water temperatures are sampled for a minute at a time and stored as a text file for analysis.

In its current state, the biomimetic AUV may serve as a platform for additional features including advanced water sampling, such as pH measurement, or underwater photography.

Acknowledgments

We would like to extend our thanks to the following individuals and organizations for their support on this project:

- The NASA Connecticut Space Grant for their generous financial assistance
- Andrew Musulin, for his endless advice and recommendations throughout the process
- Dr. Joseph Palladino, for his innovative ideas and engaging conversations
- Dr. John Mertens, for his constructive criticism and time throughout the year