Scripps Autonomous Fish

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Sponsored by Dr. Jules Jaffe & the Scripps Institute of Oceanography

Overview

This project, sponsored by Dr. Jules Jaffe at the Scripps Institute of Oceanography, serves two main purposes. The first is to create a small, quiet, low-cost, camera-equipped autonomous underwater vehicle (AUV), and the second is to generate student interest in the field of oceanography. The AUV required a design less than 20cm in length, a propulsion mechanism with low hydrodynamic and noise impact, a minimum video footage quality of 720p, and a low-cost design with an open source basis. A bioinspired approach was employed to create a unique robotic jellyfish, as seen in Figure 1 below.

Figure 1: Isometric view of the AUV

Design Components

Propulsion

Motor: high torque stepper motor[1]
Materials: silicone and steel shim stock tentacles, Makerbot 3D printed ABS motor hub, polypropylene string
Mechanism: motor hub retracts tentacles, creating a jet of water as seen in Figure 2
Tentacle stiffness allows them to return to neutral position
Characteristics: quiet, low hydrodynamic impact

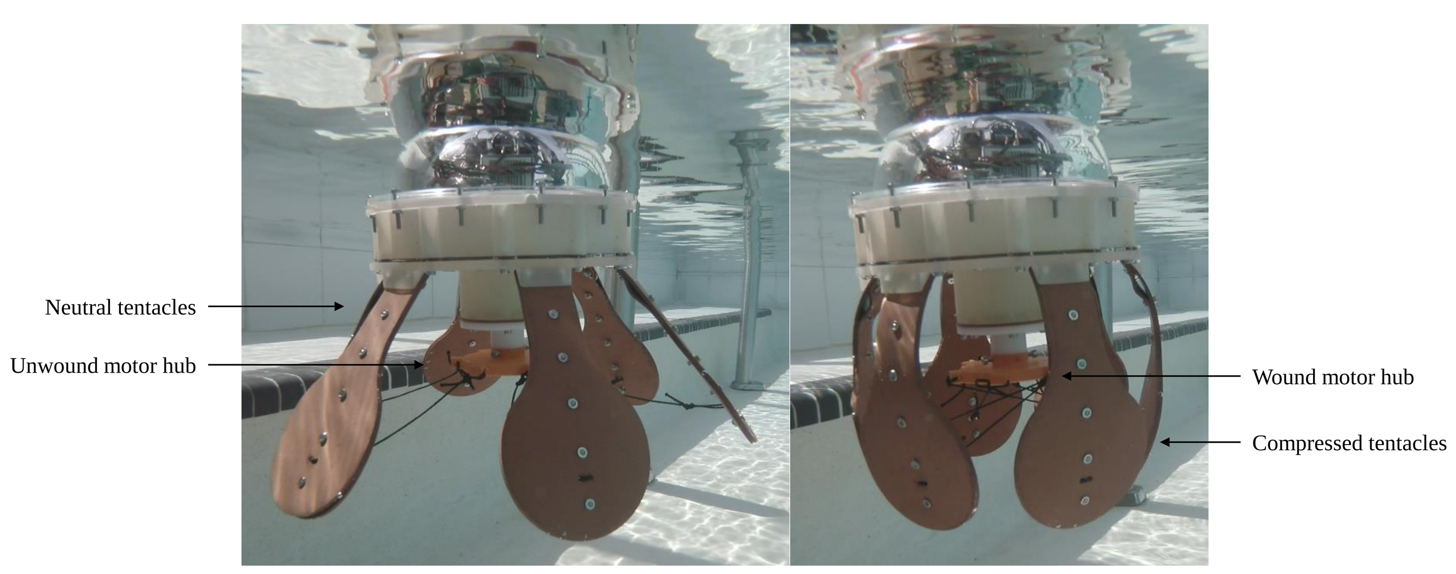

Figure 2: Neutral vs. compressed tentacle positions

Steering Mechanism

Motors: two small reduction stepper motors[2]
Materials: Makerbot 3D printed ABS gears, brass weights
Mechanism: rotates, changing the center of mass of the robot and causing it to tilt
Characteristics: 360° steering, assembled as seen in Figures 3 and 4

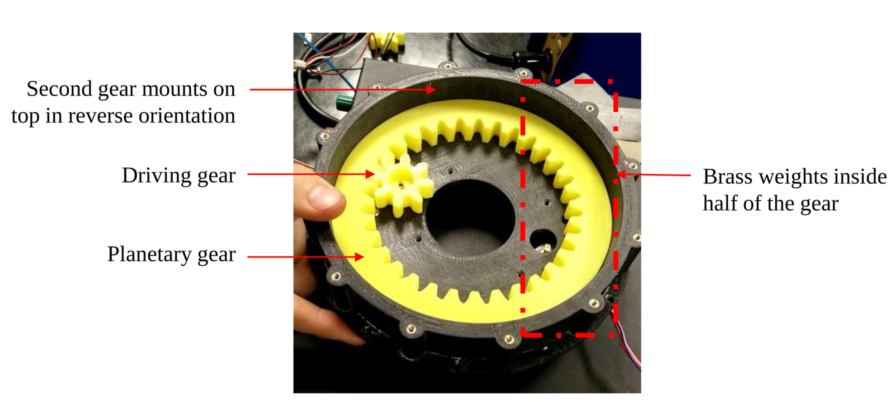

Figure 3: Internal view of the steering mechanism

Housing

Materials: Stratasys 3D printed acrylic, acrylic GoPro camera dome[3]
Characteristics: high tolerance, waterproof, custom shape

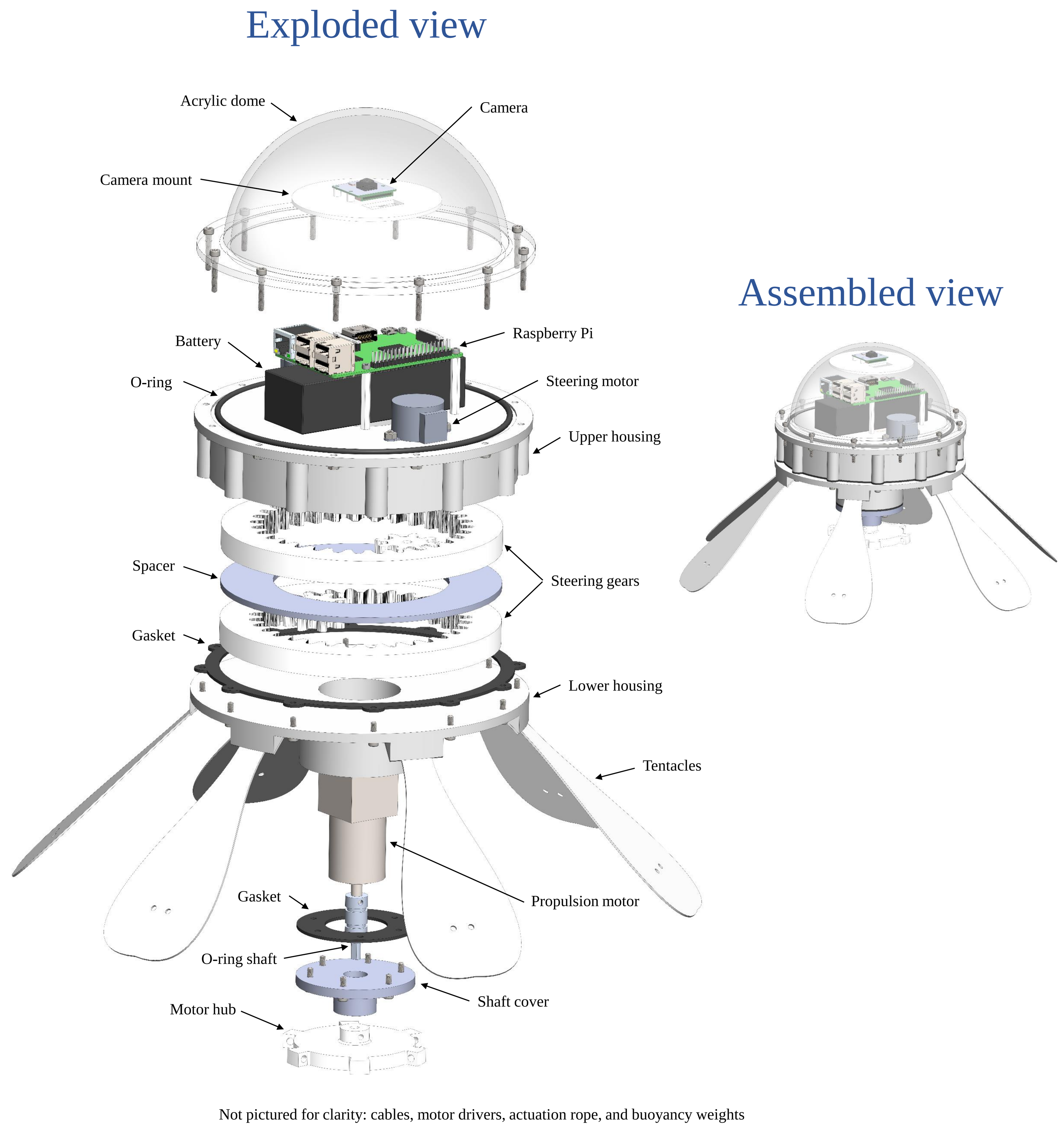

Figure 4: Overall design of the AUV

Controller and Software

Electrical components: Raspberry Pi 2 Model B[4], camera board[5], stepper motor controller boards[6],[7], WiFi module[8], 14.8V LiPo battery pack[9], micro SD card[10], voltage regulators[11],[12]
Software: Raspbian, python, OpenCV [13]
Characteristics: at surface remote communication, autonomous control, visual tracking, video recording

Waterproofing Methods

Materials: silicone O-rings and gaskets, aluminum O-ring shaft, Delrin shaft sleeve
Characteristics: three static housing seals and one dynamic rotation seal, assembled as seen in Figure 4

Theoretical Analysis

Flow Over a Hemisphere

Preliminary MATLAB calculations of flow over a hemisphere were completed to determine the forces required of the AUV, as seen in Figure 5 below[14].

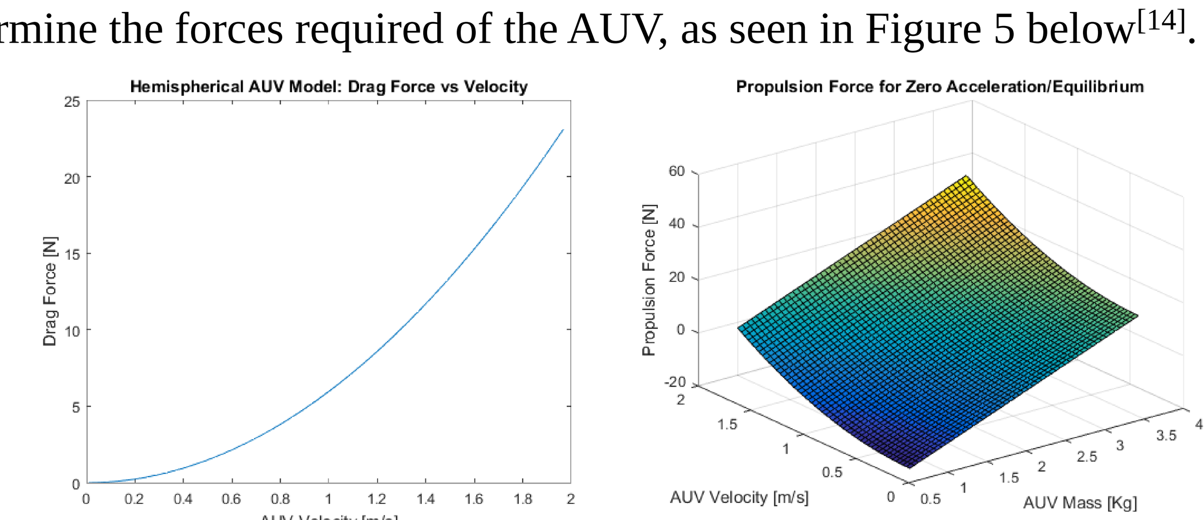

Figure 5: Flow calculations regarding AUV forces

Computer Aided Design (CAD) Mass Properties

Prototype calculations completed in Solidworks yielded preliminary information regarding the mass and volume of the design, allowing for buoyancy adjustment and steering calculations before assembly

- Center of mass: located along the central between the two steering gears
- Mass: # kg
- Volume: # m^3
- Density: # kg/m^3

Hardware Performance

Propulsion

- Dives at a rate of # m/s
- Propels upwards at a rate of # m/s

Steering

- Tilts at a 45° angle in any direction
- Reverses direction in # s

Run time

- Has an idle battery life of 12 hours
- Has an active battery life of # hours

Control

- Visually identifies objects using the camera
- Records up to # hours of video footage

Team Contributions

The project was divided based on team member interests, as well as individual strengths and weaknesses. Ciara was responsible for the CAD design/analysis, sponsor communication, and electronics selection. Damian tracked the budget, designed the tentacles, and did the majority of purchasing and prototyping for the team. Michael completed initial fluids analysis, setup and programmed the Raspberry Pi, and maintained the team website. Trevor was safety manager, machined all the necessary components of the AUV, and researched gasket and O-ring standards applied to waterproofing the robot.

Future Recommendations

In the future, the design could be improved through the following additions:

- A microscope camera
- Underwater communication capabilities
- Buoyancy control
- External charging ports
- Faster propulsion

Impact on Society and Safety Concerns

Due to the small and slow moving nature of the AUV, there are no significant safety concerns associated with operating the robot. The design is expected to have the following impacts on society:

- Create enthusiasm among high school students about ocean technologies
- Serve as a low-cost platform for quiet underwater observation
- Inspire more unique biomimetic AUV designs

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