DEPARTMENT OF MECHANICAL ENGINEERING

AquatiClaw - TEAM 20

"Team Name v37"

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Problem Definition

Our group designed a low-cost lightweight underwater manipulator to grab, sample, and inspect various objects. It was designed for use with the BlueROV, but is largely compatible with other comercial submersibles.

Applications

- UMD researchers need their submersible to have a manipulator for research
- Sampling of oysters in commercial farming
- Companies can use submersibles to remotely inspect underwater
- Repair marine machinery while submerged

Major Goals

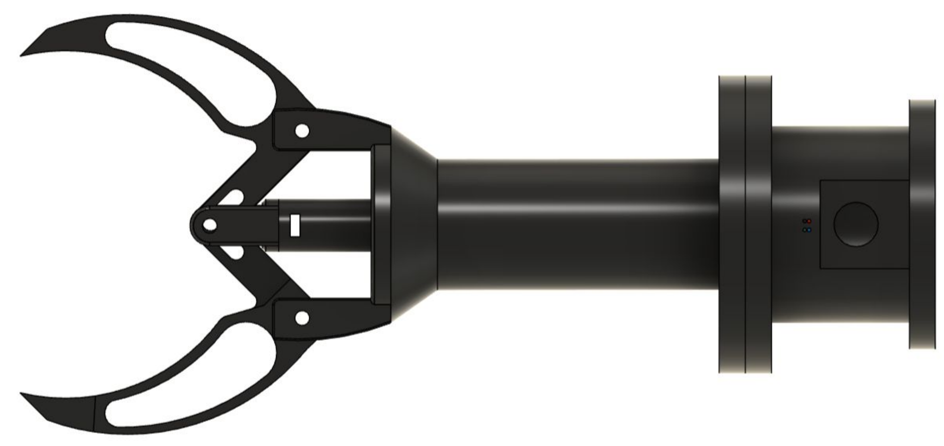
- Develop a cheap, replicable and lightweight arm
- Have a various degrees of maneuverability
- Create a remote operating system

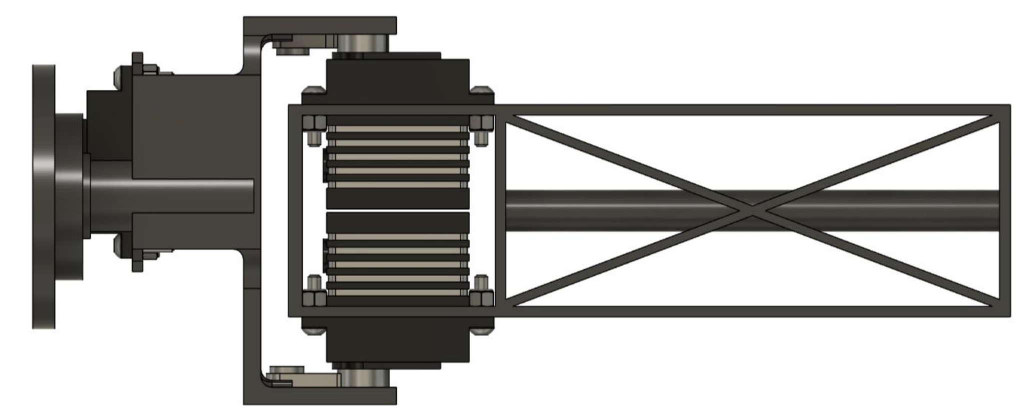
Design Constraints

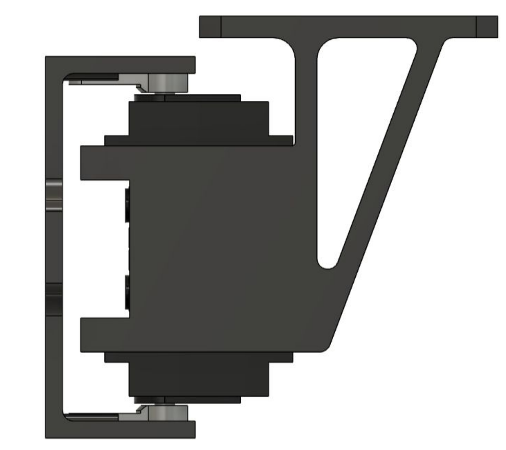
- Total weight of 3 pounds or less
- Maximum budget of $500
- 12 Volt power supply
- Minimum of three degrees of freedom

MARYLAND ROBOTICS CENTER
THE INSTITUTE FOR SYSTEMS RESEARCH

Final Design







Gripper

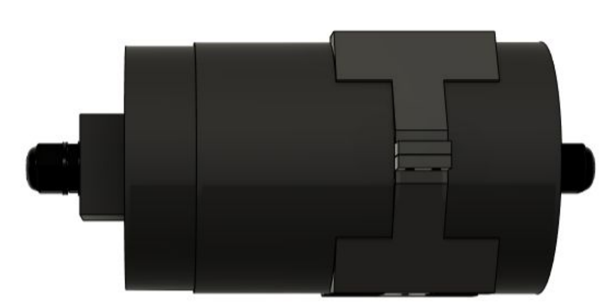
- Gripper can extend to pick up objects 1-4 inches in size.
- Claws are driven by a central threaded rod and stepper motor.
- Claws are easily interchangeable to accommodate various applications.
- 3D printed SLA and PAHT-CF

Wrist and Elbow

- Elbow and wrist joints combine with the shoulder subsystem to give 3 DOF.
- Allows user to inspect items in view of BlueROV camera
- Central tube for wire management
- 3D Printed in PLA and PAHT-CF

Shoulder

- Two shoulder base designs that mount to BlueROV payload skid.
- Two elbow mounting configurations.
- High torque servos for large lift capacity and precision control.
- 3D Printed PLA and PAHT-CF



Electronics Capsule

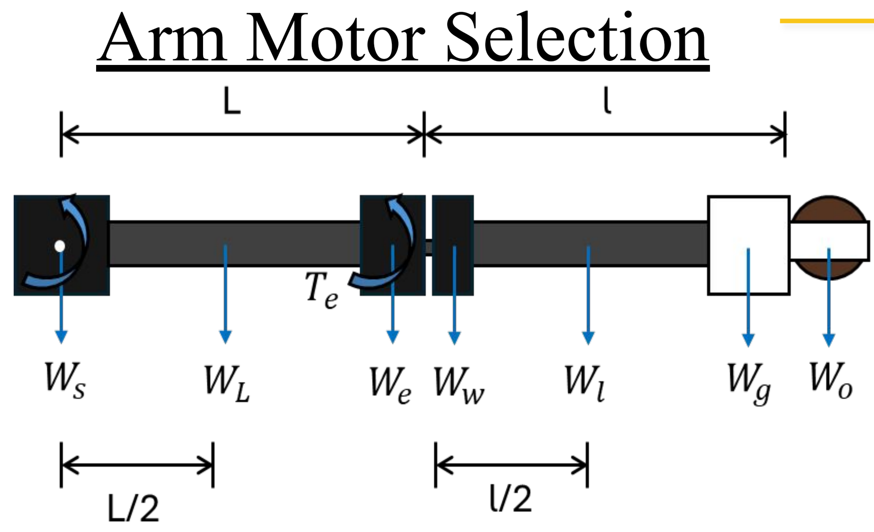
- IP66 4" PVC electronics housing
- Can be upgraded to IP68+ with BlueROV acrylic/aluminum enclosure.
- Attached to BlueROV skid with 3D printed PLA mount.

Full Assembly

- Remotely controlled using a commercially accessible Playstation 2 controller.
- Designed for ease of assembly.
- Limited mounting points allow for quick deployment.
- Modularity of various components ensure versatile application.
- Overall low cost with upgradable subassemblies to accommodate varying stakeholders

Design Calculations & Analysis

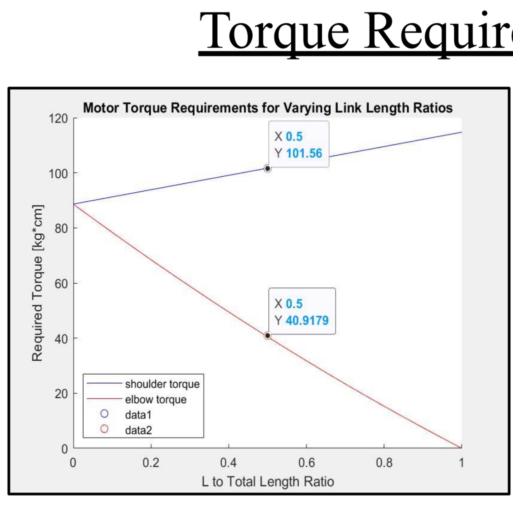
Arm Motor Selection



$$\sum M_s = 0 = T_s - (W_L)\left(\frac{L}{2}\right) - (W_e)(L) - (W_w)(L + 0.1l) - (W_l)\left(L + \frac{l}{2}\right) - (W_g + W_o)(L + l)$$

$$\sum M_e = 0 = T_e - (W_w)(0.1l) - (W_l)\left(\frac{l}{2}\right) - (W_g + W_o)(l)$$

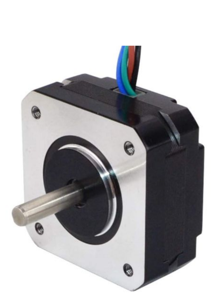
Torque Requirements



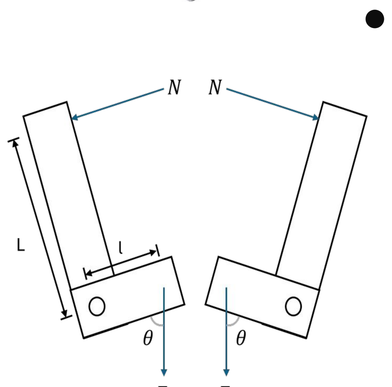
- Derived using FBD equations
- 100 kg-cm needed for shoulder joint.
- 40 kg-cm needed for elbow joint.

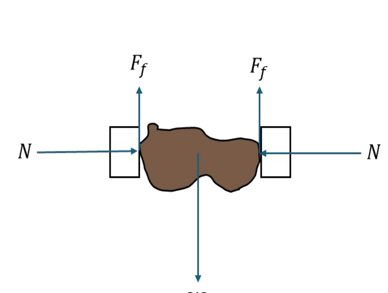
Shoulder and Elbow Motors

- Two 70 kg-cm servos for the shoulder joint
- Two 40 kg-cm servos for the elbow joint
- IP68
- 8.4V operating voltage
- 270 degree rotation



- Nema 17 bipolar stepper motor
- 12V operating voltage
- 1A operating current
- 16N-cm stall torque





$$\sum M = 0 = (N)(L) - (F_s \sin\theta)(l)$$

$$T = Fs*p/(2\pi)$$

$$\sum F = 0 = 2F_f - W$$

$$F_s = \frac{WL}{2\mu_s l \sin\theta}$$

Grip Strength

5.5-7.5 lb max grip strength

Prototype & Test Results

Waterproof Testing

- IP68 Waterproofing
  - 5 ft depth
  - 30 minutes
- 4" x 5' PVC testing apparatus
- Orange silica moisture indicating beads turn green when wet.

SLA Resin and O-Ring Seal Tests

Parts Tested

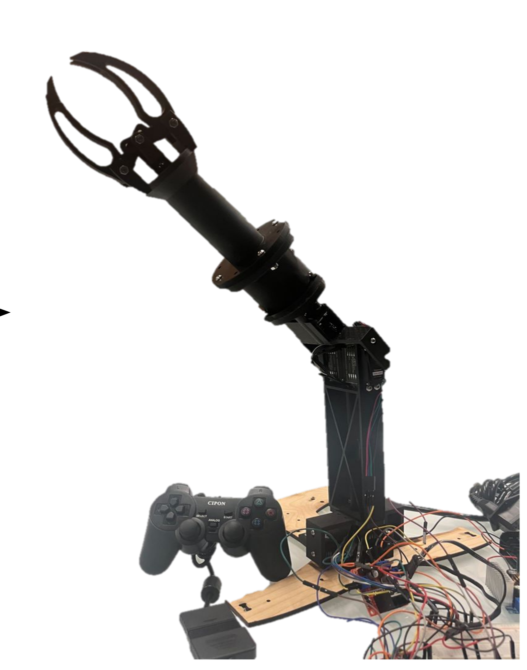
- SLA resin parts
- SLA resin seals
- FDM PLA parts (100% infill)
- Static o-ring seals
- Dynamic o-ring seals

Prototyping

10 Weeks of Evolution of the Gripper Subsystem

Low Fidelity Prototype

Medium Fidelity Prototype



High Fidelity Prototype