HYDROGRASP - ME Team 4

Low-Cost Lightweight Underwater Manipulator

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Problem Definition

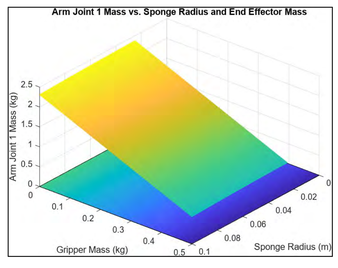
Oysters are one of the foundations of the Chesapeake Bay ecosystem and are a major target in conservation efforts. Sea sponges are often used as a marker for oyster bed health and are an invaluable tool for researchers. Currently, these sponges are recovered by divers, a costly and difficult method.

With the help of the Marine, Estuarine, and Environmental Sciences (MEES) Program director Dr. Ken Paynter, HYDROGRASP aims to provide a low-cost, user friendly platform for retrieving sea sponges and other objects of interest to study.

Design Calculations & Analysis

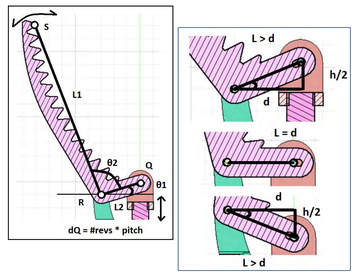
Quantitative analysis drove our design from the start. Geometries, hardware, and materials were all determined from a number of different simulations and calculations.

Joint Torque Analysis



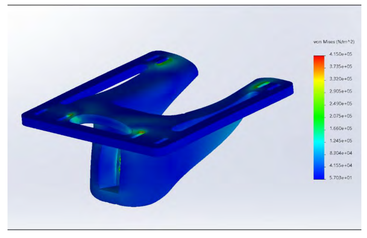
- **Evaluated maximum weight for end effector assembly**
- **Established maximum size of sponge to be grabbed**

End Effector Kinematics



- **Found required motor speed**
- **Determined constraints for gripper geometry**

Mount Failure Analysis

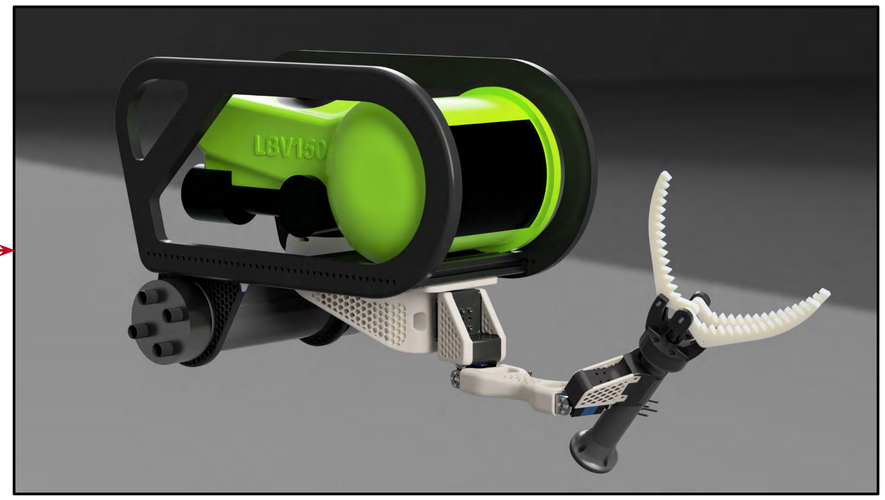


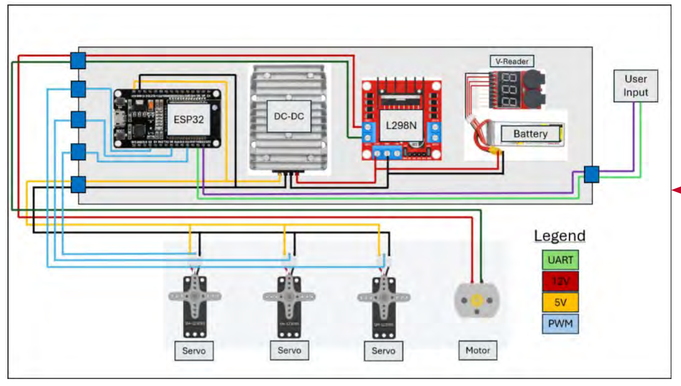
- **Located weak points in base mount**
- **Optimized geometry for tension loading**

Final Design

Key Mechanical Design Features:

- Electronics enclosed in a PVC pipe
- Servo motors waterproofed via mineral oil and epoxy
- 3 rotary arm joints
- Lead-screw actuated grabber
- End effector housing waterproofed with static seals along flanges and a dynamic seal along the linear push rod
- Honeycomb pattern applied to reduce arm weight





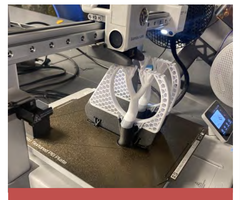
Key Electrical/Controls Design Features:

- Sub-mounted system powered via 12V battery.
- Buck converter used to step down voltage for servos, motor driver used for end effector motor.
- Arms and gripper controlled via PS5 controller .
  - Controller is bluetooth connected to an surface bound RPi which sends machine commands to an Arduino Nano which controls actuation.

Prototype & Test Results

Custom part manufacturing processes included:

- Fused Deposition Modeling (FDM) printing for linkages and mounts
- Selective Laser Sintering (SLS) printing for watertight gripper housing
- Waterjet machining for gripper jaws



Electronics Housing Mount Manufacturing

End Effector Component Manufacturing

Full Prototype Assembly

Design Evolution Study: Arm Base Bracket

Design 1 → Design 2 → Design 3 → Design 4 → Design 5