CLAMITY

The Clambot

ME 0193
Final Project

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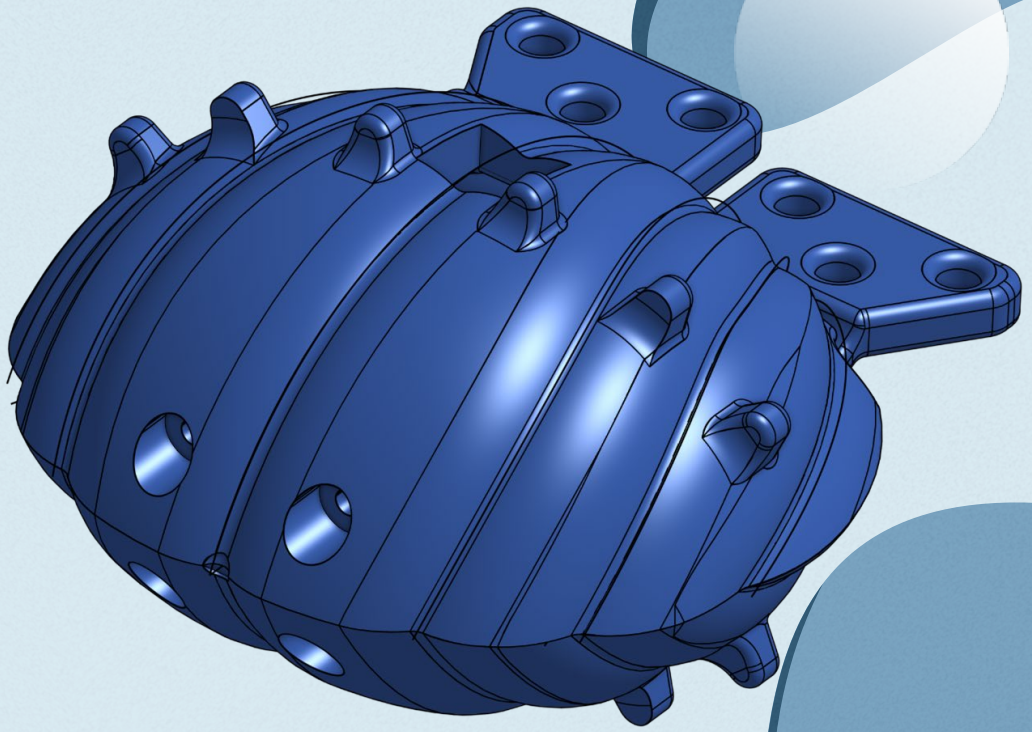


Problem

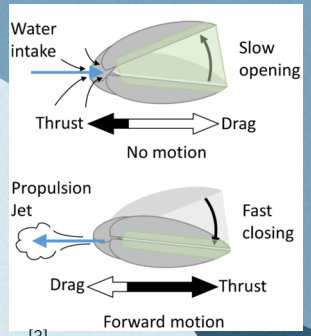
- Underwater environments are sensitive and incompatible with vehicles made of rigid materials that rely on propellers
- Underwater biomimicry fields mostly stick to fish (finned propulsion) and have not widely explored other forms of movement [1]

[1]

[1] J. Blasiak, *et al.*, "A forgotten element of the blue economy: Marine biomimetics and inspiration from the deep sea," *[Oxford Academic], 2022*

Approach

- We are taking a bio inspiration approach, attempting to model the clam's method of motion and fast closing and slow opening shell mechanism
- 3D printing soft materials (pneumatics) and harder PLA components allow for strength and compliance



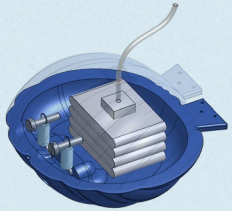
[3]

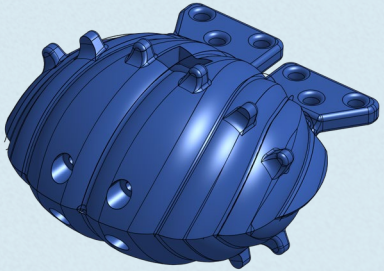
[2]

[2] u/[deleted], "A scallop swimming," *Reddit*, Jun. 30, 2013. [Online]. Available: https://www.reddit.com/r/gifs/comments/1hdch8/a_scallop_swimming/. [Accessed: Nov. 20, 2024].
[3] M. Robertson, F. Efremov, and J. Paik, "RoboScallop: A bivalve-inspired swimming robot," *IEEE Robotics and Automation Letters*, vol. PP, no. 99, pp. 1–1, Feb. 2019, doi: 10.1109/LRA.2019.2897144.

Results

- We aim to design a pneumatically powered mechanism made to slowly open and close quickly.
- Our design mimics a clams motion with the potential for underwater locomotion by syphoning water to create forward propulsion





Impact

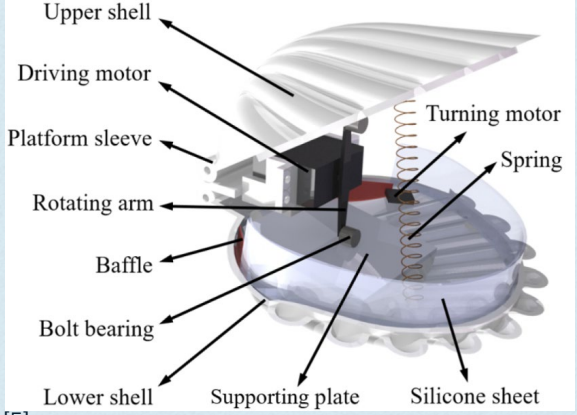
- A non-invasive robot would be ideal for underwater data collection for researchers
- This new actuation method can be used to develop new underwater locomotion systems, expanding underwater robotics

[4]

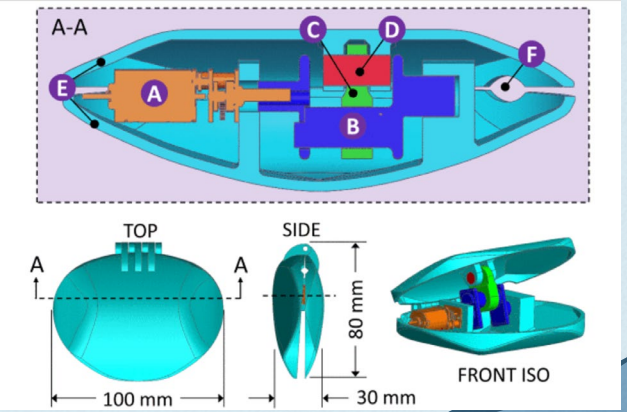
[4] OpenAI, "DALL·E image generation," [Underwater Clam soft Robot]], Nov. 2024. [Online]. Available: [URL]. [Accessed: Nov. 20, 2024].

Project Journey: Initial Research

- We read the following papers
  - [5] Wang, Y., Pang, S., Jin, H., Xu, M., Sun, S., Li, W., & Zhang, S. (2020). Development of a biomimetic scallop robot capable of jet propulsion. *Bioinspiration & Biomimetics*, *15*(3), 036008–036008. https://doi.org/10.1088/1748-3190/ab75f6
    - Uses a spring to apply faster closing
  - [3] Robertson, M. A., Efremov, F., & Paik, J. (2019). RoboScallop: A Bivalve Inspired Swimming Robot. *IEEE Robotics & Automation Letters*, *4*(2), 2078–2085. https://doi.org/10.1109/LRA.2019.2897144
    - Used motors for controlled slow opening and fast closing
- Liked the first papers idea of use of a spring to create a naturally closed state to mimic the slow opening and fast closing motion that propels the clam through the water
- Decided on an approach that utilizes a naturally closed state with multiple springs and a pneumatic actuator instead of the motorized approach used in both papers



[5]



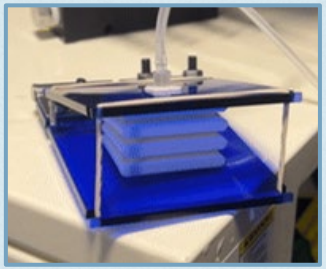
[3]

Project Journey: Design Iterations

Actuator Test

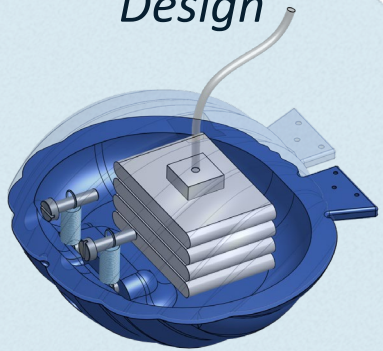
- Extended 3D printed linear actuator
- Laser cut acrylic top/bottom mimics rigid shell
- Rubber bands for fast closing
- Closing 4x faster than opening

Hinge Test

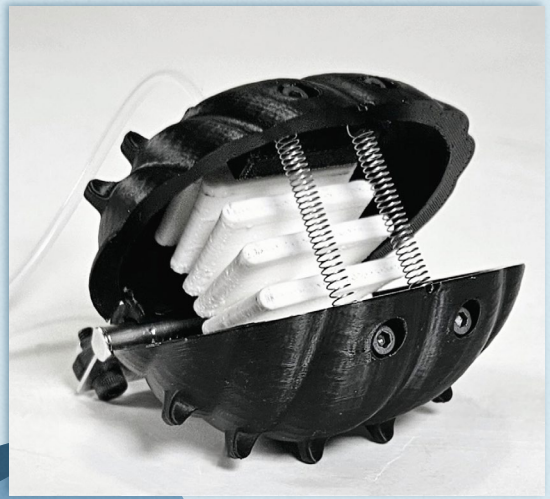


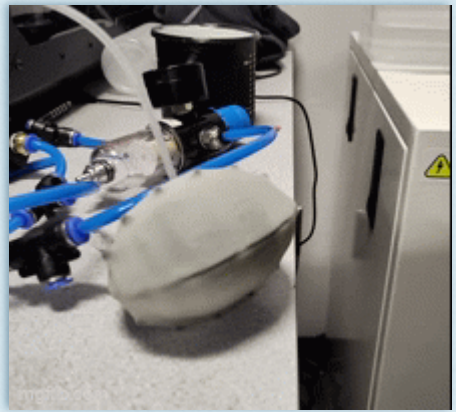
- Incorporated a hinge to achieve intended motion
- Modified linear actuator to nestle and connect to acrylic
- Closing 2x faster than opening

Shell Design



- Designed a PLA shell
- Houses linear actuator and opens with a hinge
- Incorporates springs held in place by screws
- Closing 3x faster





Final Design

- Modified shell design
  - Added back vets for jet propulsion
  - Added hooks to attach a balloon membrane
    - Ballon siphons water back out the vents to move the clam forward
- Tested at 170 kPa (underwater)
  - Complete closing in 0.07s
    - Fastest closing speed we've achieved
  - Opening in 0.12s
  - ~2x ratio
- Pressure required for full actuation is too high for micro pumps and valves

Project & Course Takeaways

3D Printing

- More practice troubleshooting and fixing 3d printers
- Found optimized settings for consistently airtight prints.

Fluidic Actuation

- Powering actuators with pressurized fluid vs electronics
- Designing fluidic actuators
- Pneumatic circuit understanding

Prototyping

- Verified the importance of testing each step along the way
- Made it easier to move to the final prototype and have it work the first time

Thanks!

Any questions?