Bio-inspired Pneumatic Amphibious Soft Robot: Implementation and Motion Analysis

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Abstract

Our project has successfully manufactured a functional amphibious soft robot via additive manufacturing. The robot is capable of swimming at a maximum speed of 0.40 BLS (Body Lengths per Second) and walking at a speed of 0.01 BLS. We observed that incorporating grooves and fin-like structures enhanced the robot's swimming capabilities, enabling faster and more stable movement under the same condition. Additionally, we have introduced an sawtooth limb design to facilitate ground locomotion. We anticipate that this robot could be instrumental in wilderness exploration where hard robots and humans face limitations.

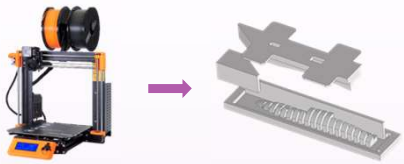
Objectives

Current exploration robots lack adaptability to different environments, while soft robots, with their excellent flexibility and deformation capabilities, can adapt to narrow spaces like caves. We take inspiration from nature, using the salamander as a reference to mimic its terrestrial crawling and swimming abilities. This project utilizes 3D printing to create a soft robot structure capable of both swimming and crawling.

Materials and Method

- Manufacturing process：

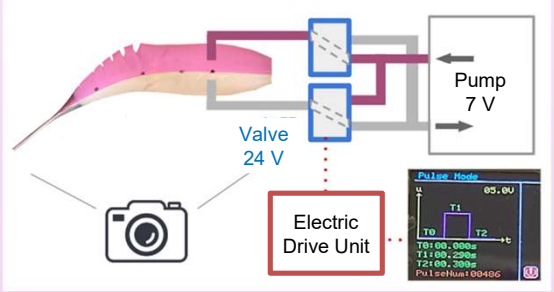
- 3D Printing Molds：



- Preparation of silicone and casting：

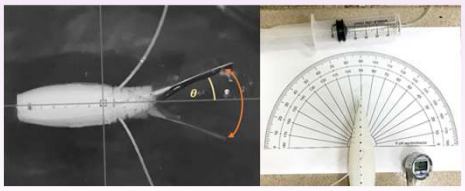
- Pipe installation and Sealing：

- Schematic diagram of the system setup：



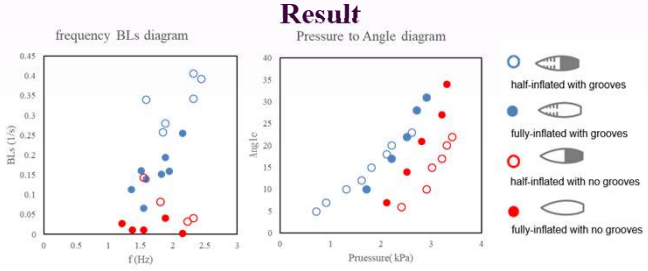
- Testing of crawling and swimming capability：

- Swimming Capability Analysis:
  Swing Frequency, Moving Speed, Angle, Pressure



＊ Analysis software：Tracker

Result



- The comparison of swimming speeds in water:

- The comparison of tail wagging angles:

Conclusion

•Robot mobility powered by tail fin thrust; **enhanced tail swing** at same air pressure due to concave **groove structure.**

•Robot motion linked to tail activity; chamber restriction in rear half boosts efficiency and speed.

•**Increased frequency** leads to **faster swimming speeds** in robot, aligning with existing literature.

•**Sawtooth limb structures** on the robot **enhance friction**, facilitating crawling capabilities.

Reference

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2. Marchese, Andrew D., Cagdas D. Onal, and Daniela Rus. "Autonomous soft robotic fish capable of escape maneuvers using fluidic elastomer actuators." Soft robotics 1.1 (2014): 75-87.
3. Schiller, Lars, Arthur Seibel, and Josef Schlattmann. "Manufacturing, control, and performance evaluation of a gecko-inspired soft robot." JoVE (Journal of Visualized Experiments) 160 (2020): e61422.

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