ME193

Final Project
SlitherSense

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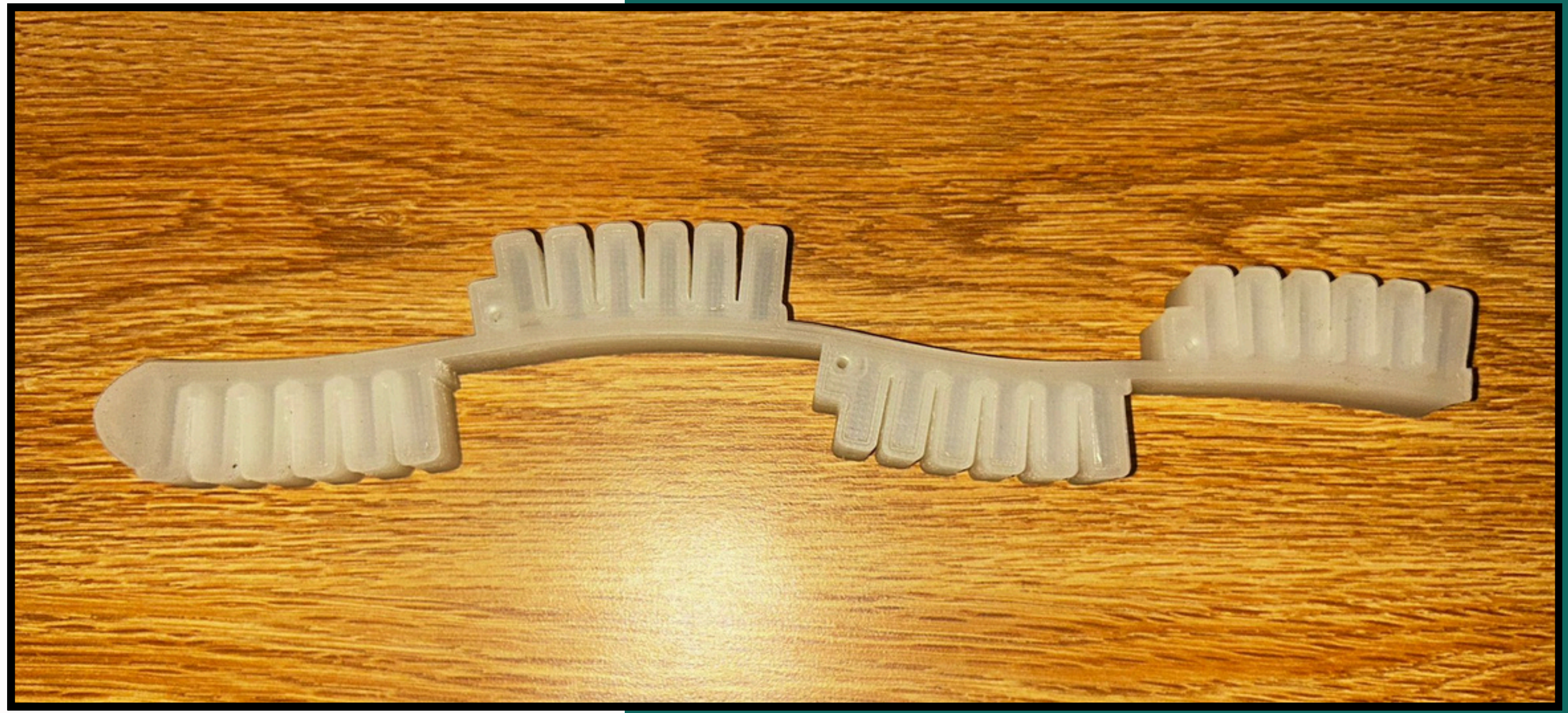
and Migdalia Lopez



Problem

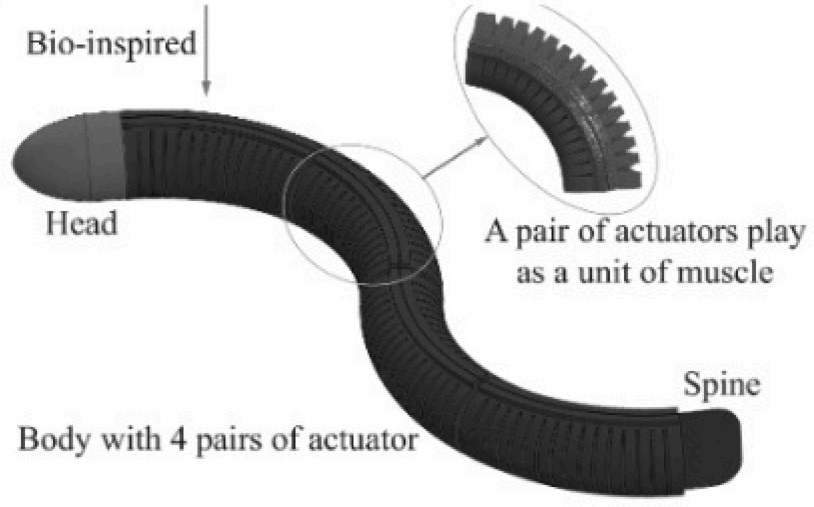
- Pests are responsible for **20-40% of global crop losses annually**, posing significant threat to food security [1].
- Traditional pest detection methods often fail to operate effectively in dense crop environments, leaving significant portions of fields vulnerable to undetected pest infestations.

1] L. Gula. "Researchers Helping to Protect Crops from Pests," *National Institute of Food and Agriculture (NIFA)*, 2022.

Approach

Design inspiration taken from [2]

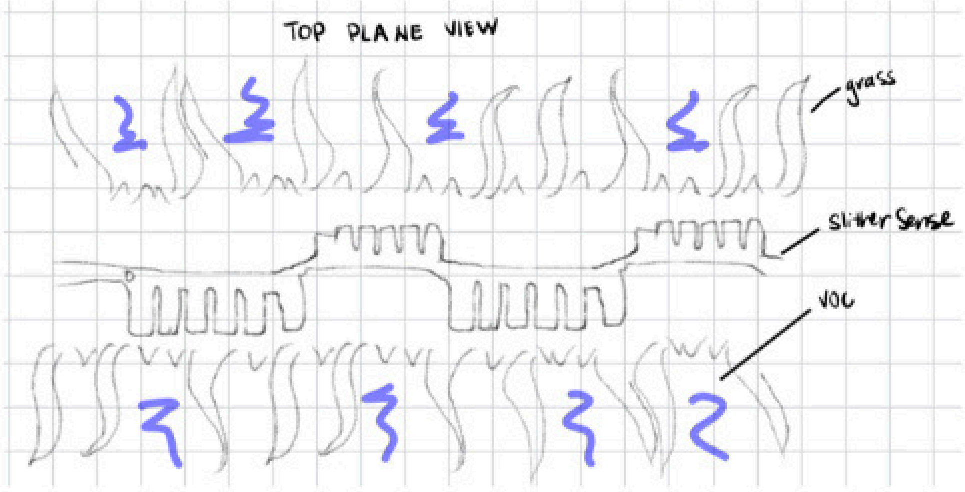
- Design inspired by snake-like movement, using side-to-side slithering in an anguilliform pattern to navigate dry land and varied terrains in a multidirectional way
- An FDM TPU printed bending actuator that can bend in two directions



[2] D. Q. Nguyen and V. A. Ho, "Anguilliform Swimming Performance of an Eel-Inspired Soft Robot," *Soft Robotics*, 2021.

(Anticipated) Results

- A design incorporates a pneumatic actuator that bends left and right with each airflow pump
- Constructed with flexible materials to adapt to different surfaces and contours without damaging environment
- Reach Goal: Use a ENS160 Gas sensor to detect VOCs



Made with AI Dream Lab photo generator

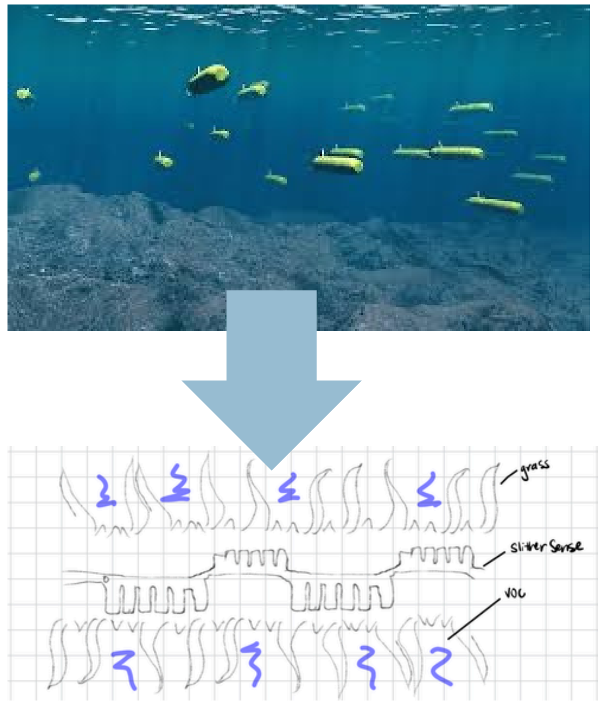
Impact

- Improve pest control in dense crops by increasing crop yield, reduce environmental impact, and detect specific pests
  - Farmer livelihoods
  - Increases crop yield supporting food securities

https://www.nrcs.usda.gov/resources/guides-and-instructions/pest-management

https://www.agrivi.com/blog/natural-pest-control-in-organic-farm-systems

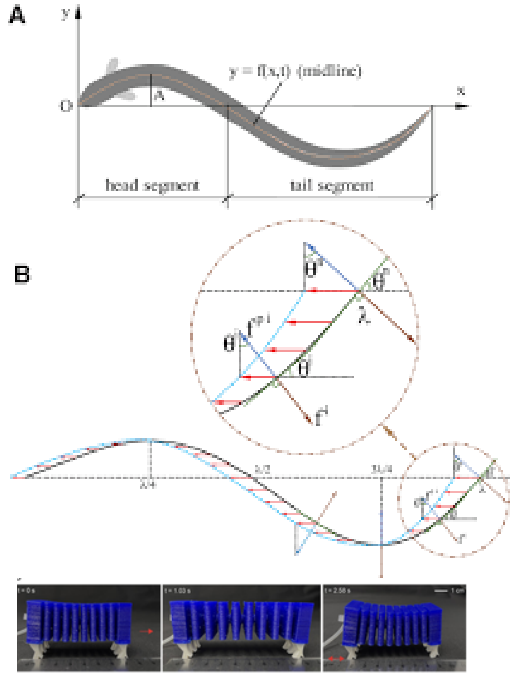
Project Journey



Planning Stage

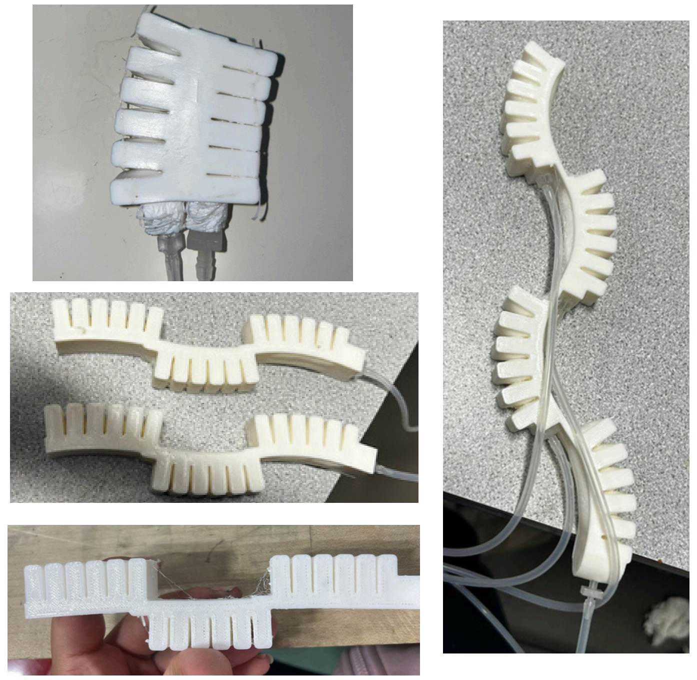
From underwater mission robots to quickly realizing NinjaFlex 83A is too dense, we changed trajectory of plans 3 times!

1. Underwater slither cleaner with appendages
2. Cave rescue mission robot
3. Snake-Inspired robot



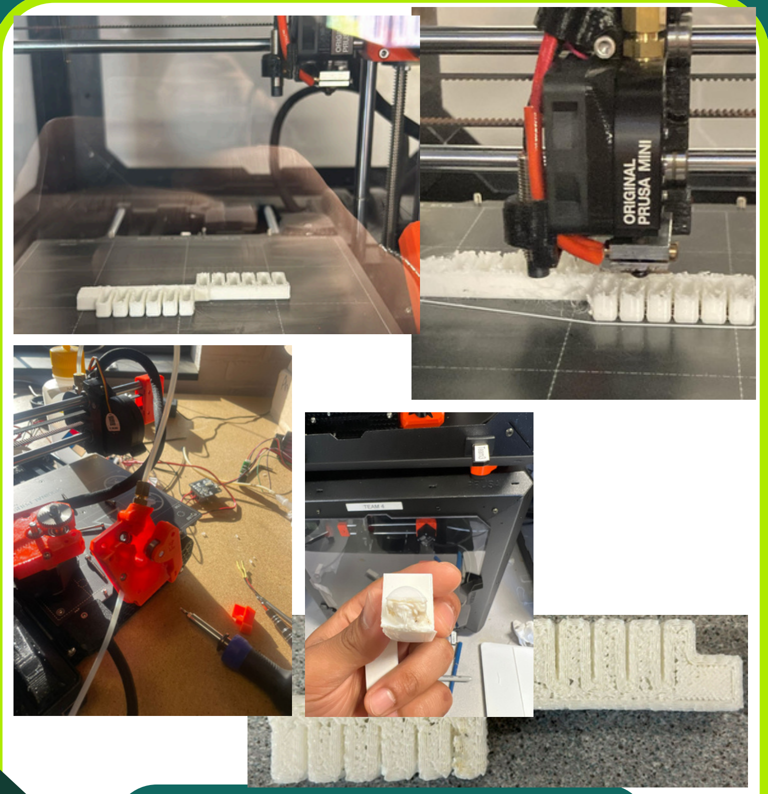
Making Informed Decisions

- Explore anguilliform motion v. carangiform
  - high propulsive efficiency [1]
- Learn more about agility and models currently being used [2]
- Decide if our model will need external attachment pieces [3]



Design Ideation Stage

Tried 4 different designs
Ended up with 1 final idea

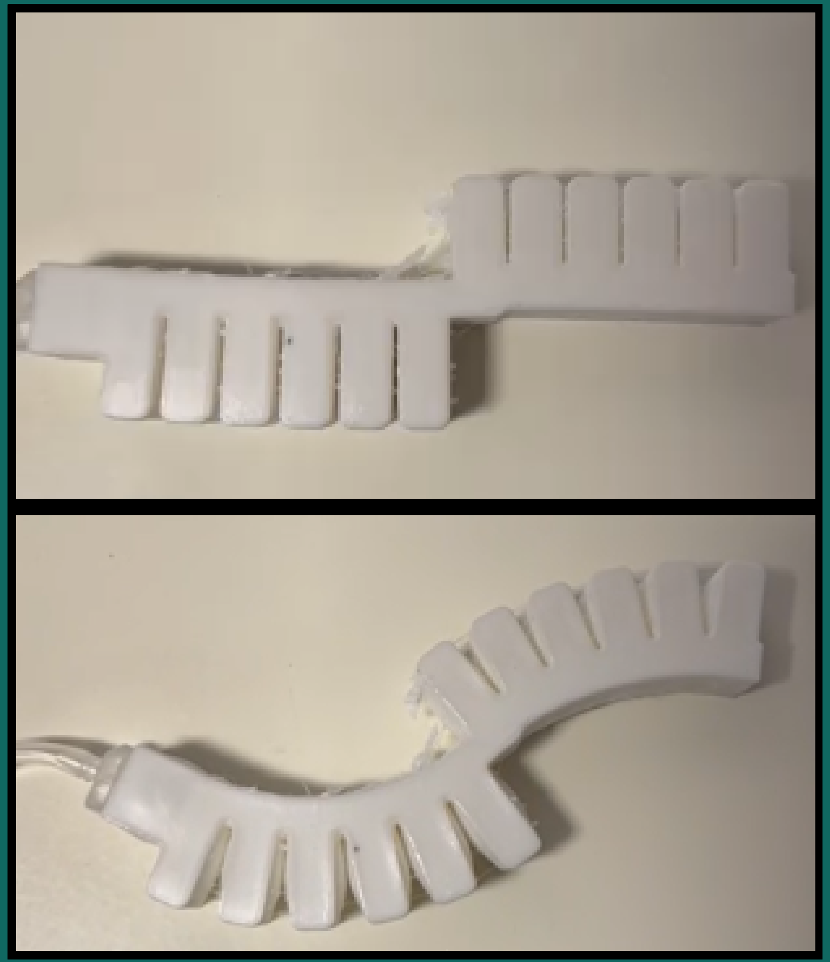


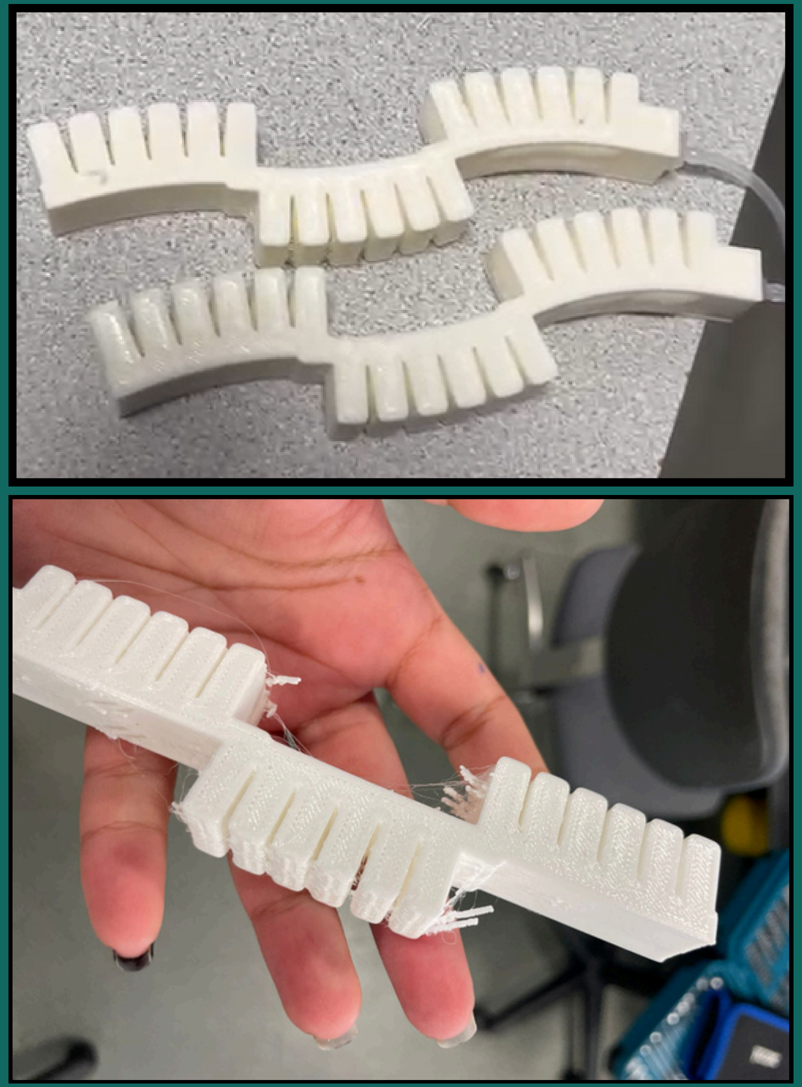
Printing Issues

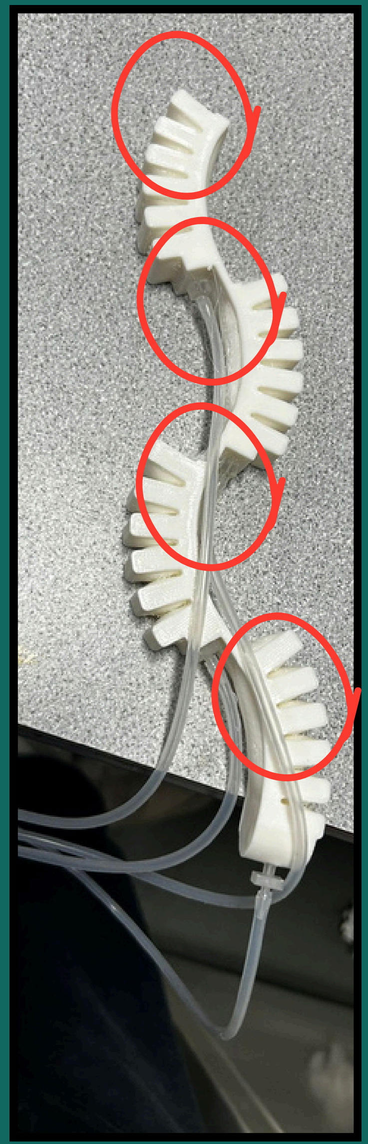
Printing issues with:

- Buckling
- Under extrusion
- Filament jamming
- Stringing
- Poor layer adhesion
- Calibration

Our Designs







Double Actuators Bend

- Connected pneumatically by one single input
- Decent bend
- Actuates quicks
- Move up to 3 or 4 actuators

Triple Actuator Bend

- Similar design as the double bend
- Low movement, too stiff
  - <10 Degree bend even with high pressures

Stacked Double Bend

- Two stacked actuators separate but connected
- 2 inputs that control the direction of bend
- Too stiff, low movement aswell
  - <10 Degree Bend

Quadruple Actuator

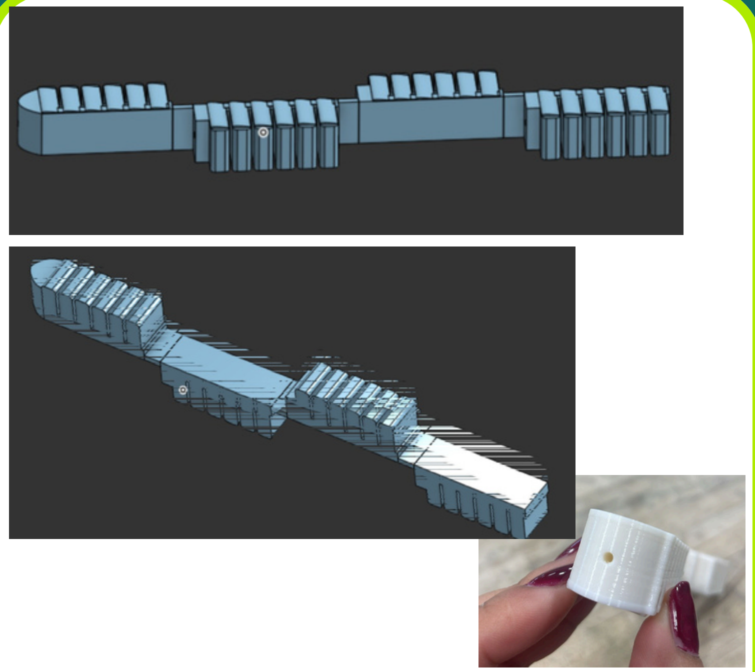
- 4 Actuators connected but not pneumatically connected
- 4 separate inputs for more control
- Improved bending, providing greater freedom for control.

Project Journey

Proof of Concept Stage

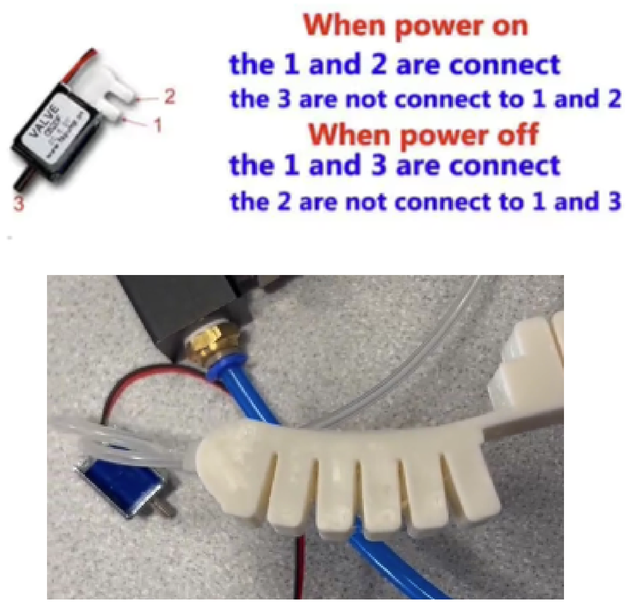
Finally having success with a quadruple bend:

conduct extensive testing of various actuator **patterns** to identify those that **optimized** controlled **movement** and **maximized** displacement.



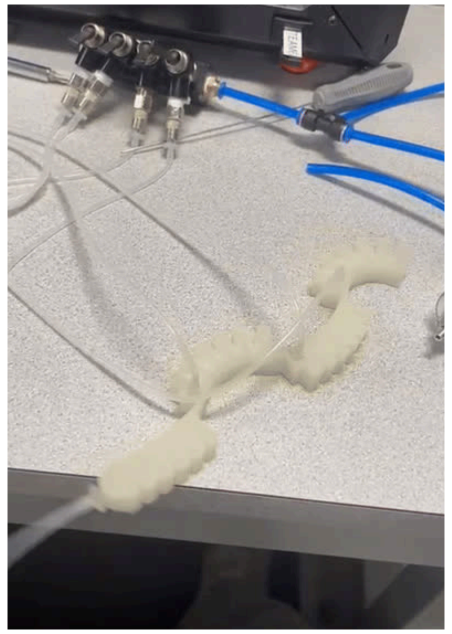
Final Design

- 4 inlet holes to be tethered placed on the top to improve positioning
- Scales to help with mobility
- Thinner inextensible layer for more movement



Hardware Troubleshooting

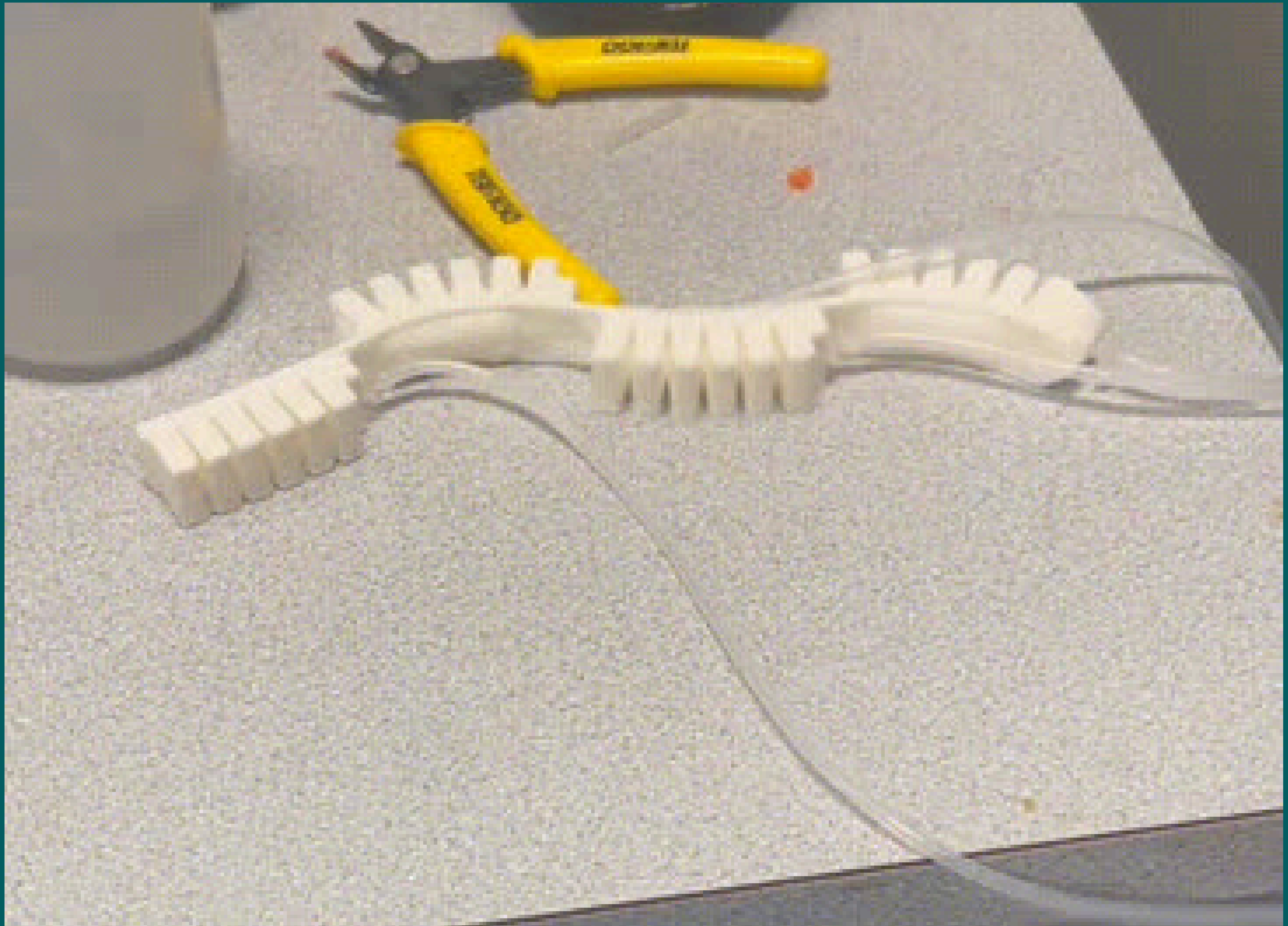
- Solenoid valves did not work for our application
  - unable to sustain pressure difference
- Power/current issues
  - Arduino & solenoids required too much current



Continued Improvement

- Printed our final design with 40A pellet filament to get more bend at lower pressure
  - Successfully navigate dry land and varied terrains in a multidirectional way
- Future improvements: Add ENS160 VOC sensor

Demo



Improved Demo

click here for videos

3 Big Takeaways

Print Parameters

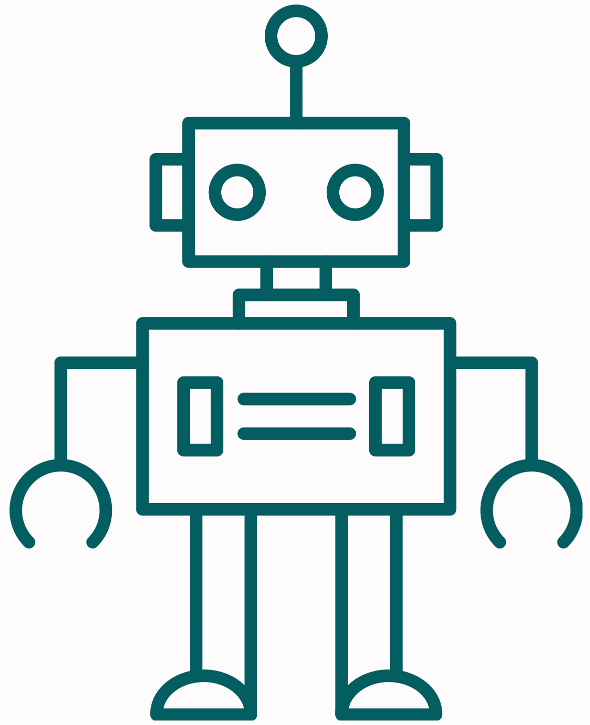
- Importance of print parameters such as print speed, extrusion multiplier, infill percentage, layer height, and Z calibration played a role in our prints each time

Design & Creativity

- Learned how to find creative solutions to shape the design
- Developed movement mechanisms through an iterative process, adapting designs as needed

Understanding Scope

- It's important to clearly define the scope—understanding the functional requirements, limitations, and timeline
- Weekly check-ins helped us ensure that the project remains aligned with vision while accommodating new insights



THANK YOU

Professor Nemitz
Savita Kendre
Cem Aygül
for all your help and support!

[1] D. Q. Nguyen and V. A. Ho, "Anguilliform Swimming Performance of an Eel-Inspired Soft Robot," Soft Robotics, 2021.

[2] L. Gula. "Researchers Helping to Protect Crops from Pests," National Institute of Food and Agriculture (NIFA), 2022.

[3] S. V. Kendre, C. Aygül, C. S. Page, L. Wang, and M. P. Nemitz, "FDM Printed CMOS Logic Gates from Flexing Beam Mechanisms for the Control of Soft Robotic Systems," Advanced Intelligent Systems, pp. 2–16, 2024. Available: https://sites.tufts.edu/nemitz/files/2024/11/2024-kendre-comliant-mechanism-logic-gate-main-manuscript.pdf