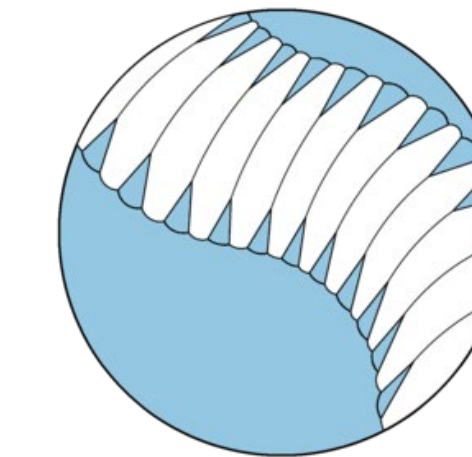




# WPI

# Soft Robotic Eel

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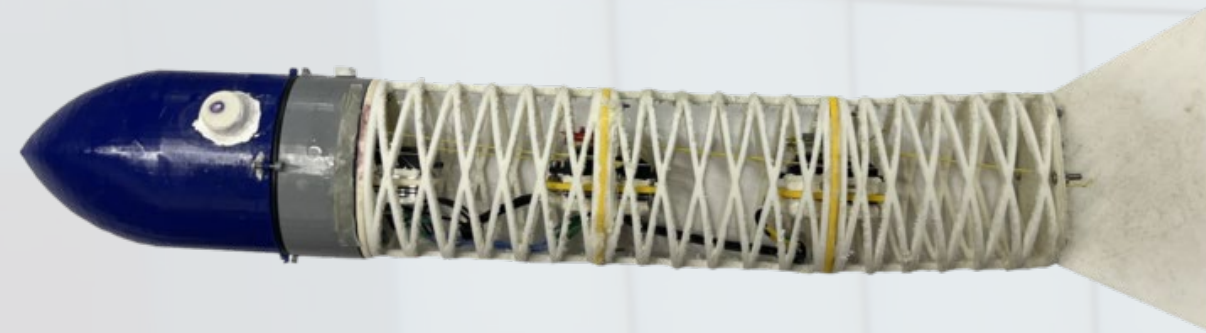


SOFT  
ROBOTICS  
LAB

Advisors: Cagdas Onal (RBE), Robin Hall (RBE)

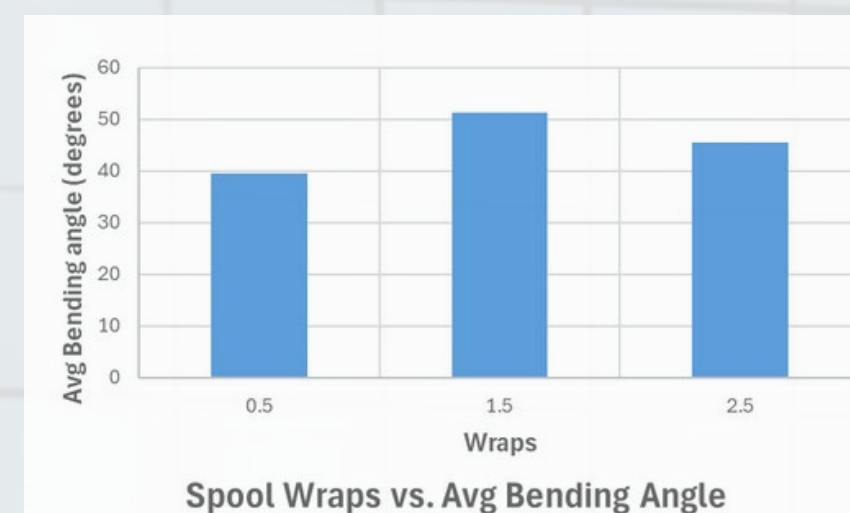
## Overview and Objectives

- Expanded on previous project
- Increase movement speed
- Propulsion through anguilliform movement
- Allow for future scalability
- Modular design



## Testing

- Bending angle
- Speed
- Material
- Water tightness



## Software

- Bend angle is based on sine wave function
- Amplitude:  $120^\circ$
- Frequency: 1 Hz
- Phase Shift:  $2\pi/3$

```
// Most important function
// Frequency is the oscillation frequency (how fast the servo moves back and forth)
// Phase shift controls coordination between servos
// Amplitude is how much each servo moves from center (one for each servo)
// and how fast frequency, float phaseShift, float amplitude, float amplitude, float amplitude)

// 2 * PI converts frequency from Hz to radians per second
float angle = frequency * 2 * PI; // radians/second

// calculate the angle for each servo
// angle = center + amplitude * sin(frequency * time + phase shift)
angle = center + amplitude * sin(frequency * time + phaseShift);
angle = center + amplitude * sin(frequency * time + phaseShift);
angle = center + amplitude * sin(frequency * time + phaseShift);

// write angle to servo
servo.write(angle);
servo.write(angle);
servo.write(angle);
servo.write(angle);

float shortestPath(float currentAngle, float targetAngle) {
  float diff = targetAngle - currentAngle;
  if (diff > 180) return targetAngle - 360; // Adjust to take the shorter path
  if (diff < -180) return targetAngle + 360;
  return targetAngle;
}
```

## Challenges

- Accordion Segments
  - Difficult to print and repair
  - Prone to tearing
- Motors
  - Limited torque output
  - Constrained by internal space
- Electronics
  - Small watertight compartment
  - Tight wiring layout
  - Limited space for battery



## Head

- Houses battery and control board
- All components are 3D printed from PLA to protect delicate parts during motion
- The battery compartment is also designed to house future sensors
- Acrylic conformal coating was added to all compartment surfaces

## Waterproofing

- Protecting the ESP32, PCB and servos from water was a top priority
- Marine-grade epoxy was applied to servos and wire connectors
- The ESP32 is enclosed in a watertight compartment within the head module

## Modules

- Houses  $360^\circ$  servo motor and spool of fishing line
- Bends by rotating spool to pull on the passive end
- Each module can bend up to  $\sim 51^\circ$  in either direction from center

## Tail

- Final module of the eel
- Passive design
- Uses existing momentum for forward propulsion
- Tail end is constructed from NinjaFlex, a more rigid yet flexible TPE