Mobility Study of Multi-Joint Driven Robot Fish

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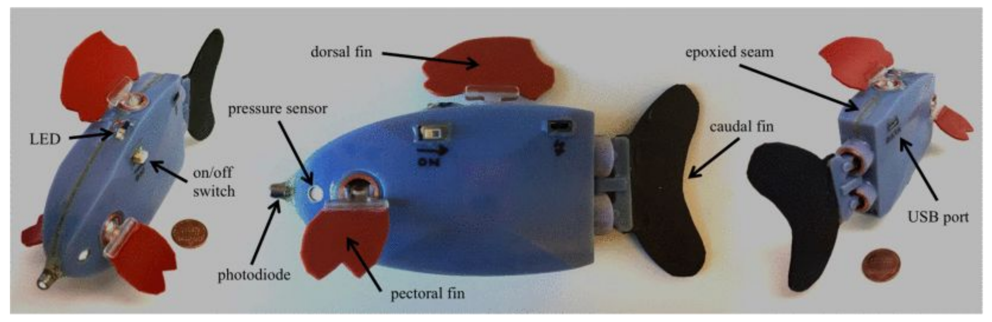
24775, Bioinspired Robot Design, Mechanical Engineering

Introduction

Motivation

Fish are able to maneuver quickly and easily in water by using their long, flexible tail. Many robots have tried to mimic their movements, a few which are shown below. Our project aims to build on previous research on fish-like underwater robots by designing and building a robotic fish with a tail that uses three servo motors chained together, in order to analyze how different tail speeds and stiffnesses of the tail affect its mobility.

Previous Work



This robotic fish uses four motors to move.

This wire-driven robotic shark was developed for better maneuverability.

Method

Fish Body Wave Reconstruction

The ideal fish body wave is sine-like as reconstructed in Fig. 1 and we simulated it with a three-end servo system as shown in Fig. 2.

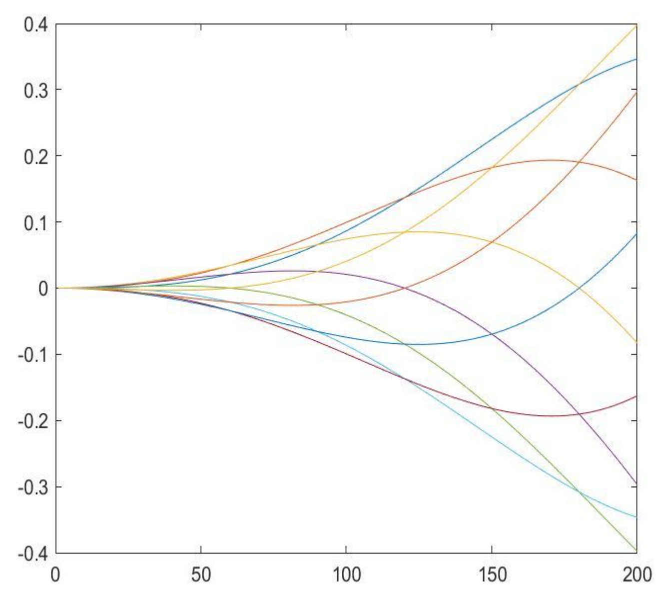


Fig. 1

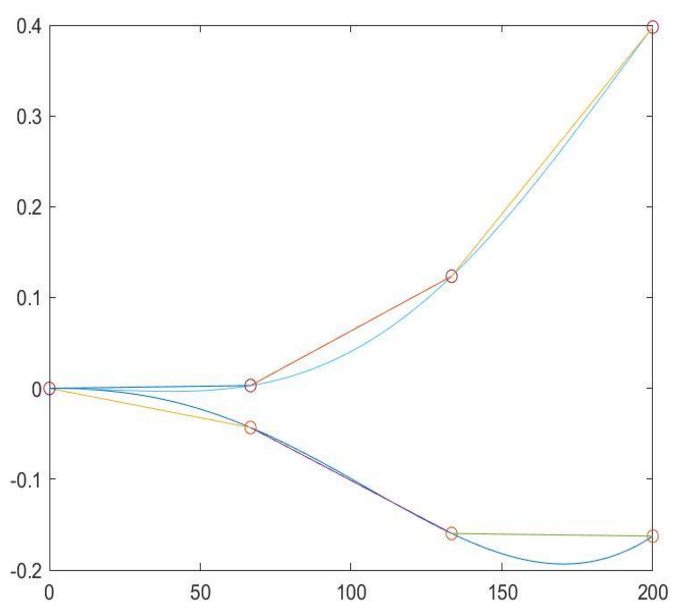


Fig. 2

After we apply the skew coefficient and magnitude coefficient to the wave function, we can obtain turning wave function for fish body.

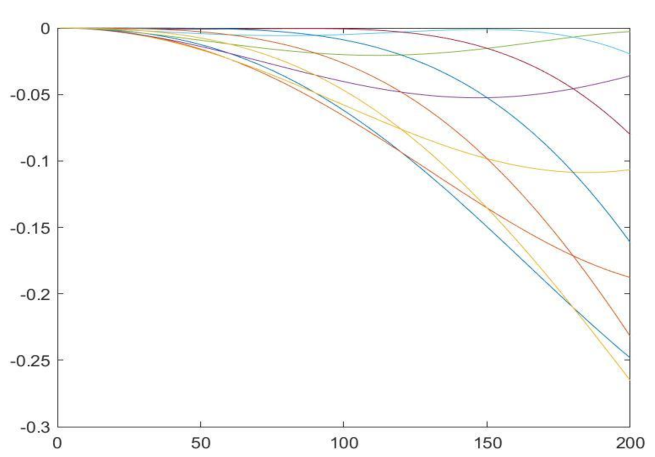


Fig. 3

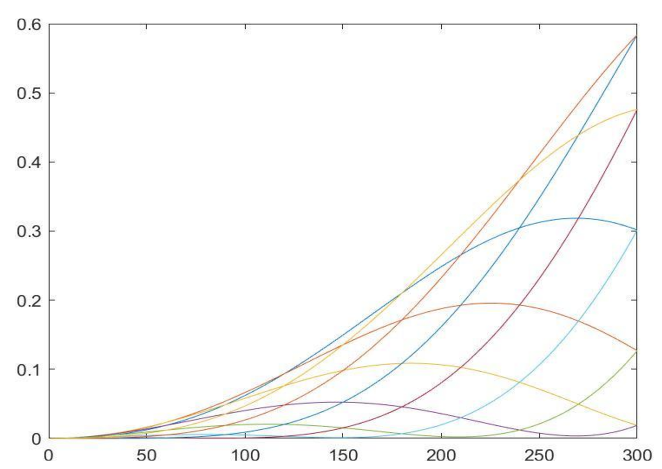


Fig. 4

Method

Remote Control Design

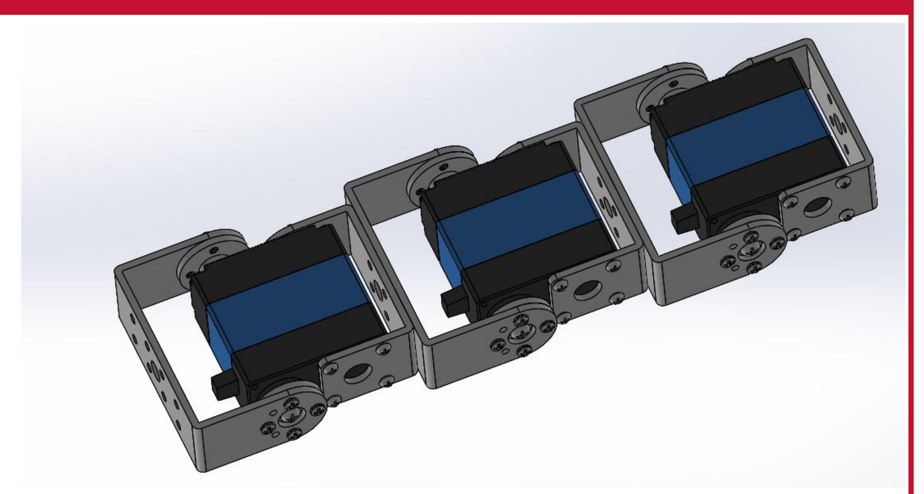
Arduino Modules

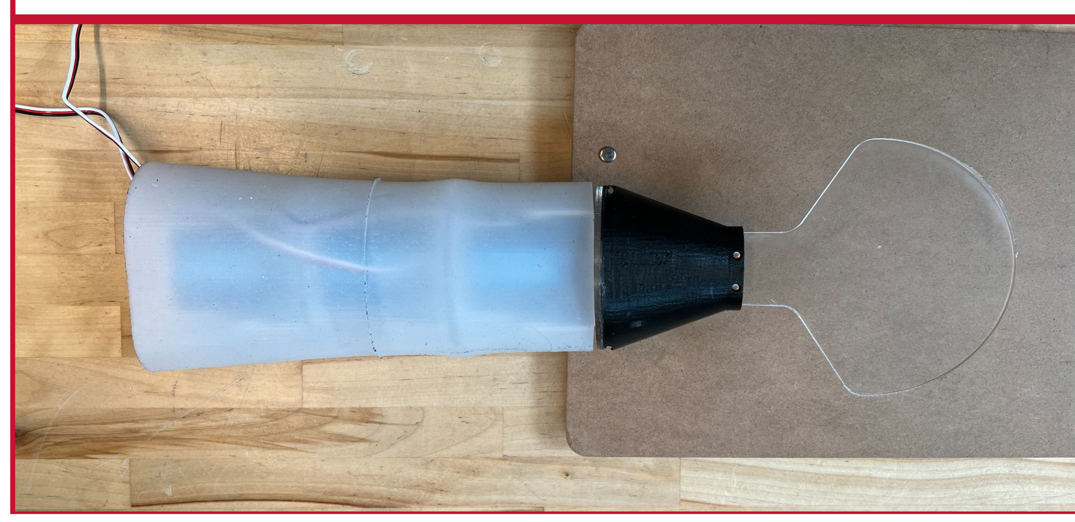
SD Card Records gyroscopic data while testing	**DHT** Senses the humidity to indicate any leaks	**Remote Communication** Allows for external mode changes
LED Indicator Indicates the current state of the robot	**Gyroscope** Obtains acceleration and velocity data	**Servo** Controls the servo motors to mimic fish tail motion

Mechanical Design

The head of the fish holds the sensors and arduinos. It is fully waterproof to allow the robot to be untethered.

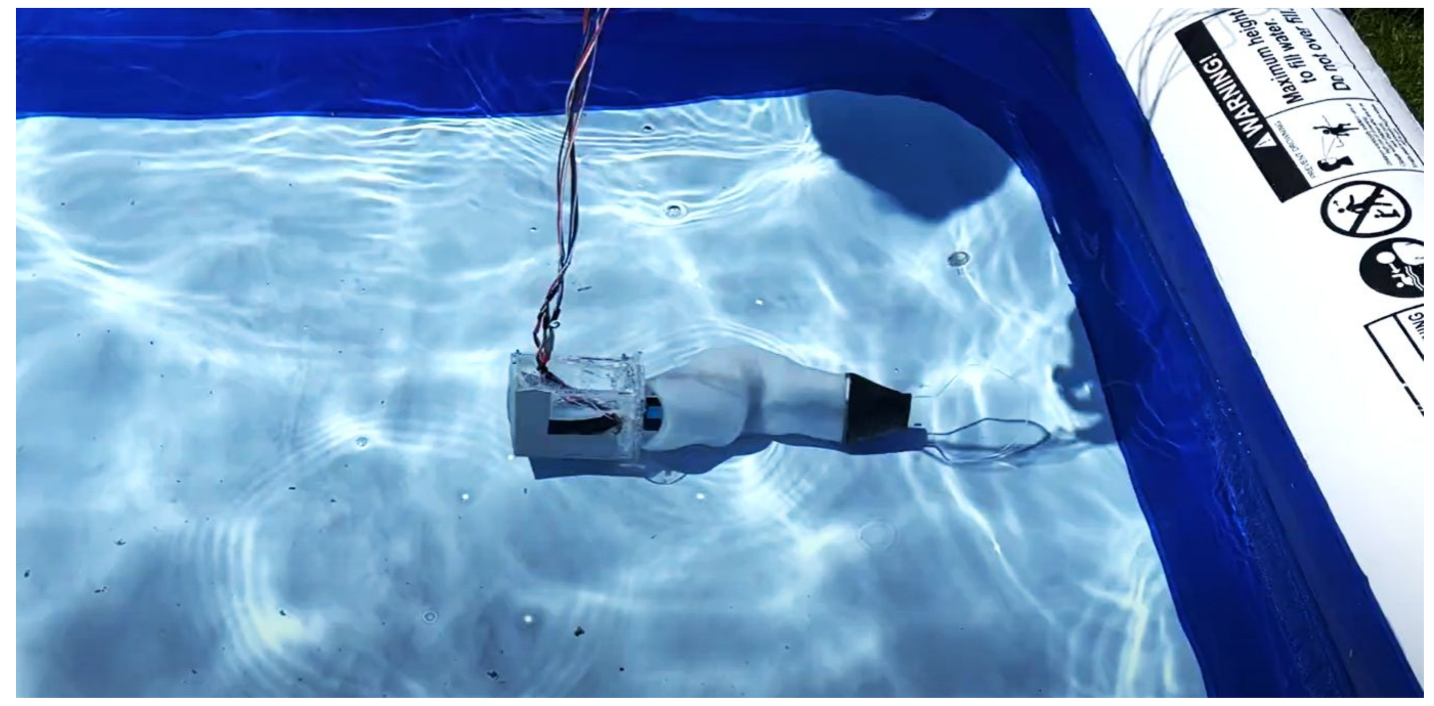
The motion of the tail is controlled by 3 waterproof servos chained together. These can be enabled or disabled to simulate different stiffnesses





The tail of the fish surrounds the motors with a flexible silicone shell, with a 3D printed tail attachment on the last motor

Experimental Plan



Testing was done in an inflatable pool using 2 sets of variables

Low Tail Frequency and Amplitude ⟷ High Tail Frequency and Amplitude

1 Servo → 2 Servos → 3 Servos

Results

Observational results for speed levels (3 active servos)

Speed Level	Forward Speed	Directional Stability	Turning Stability
1	Nearly None	Nan	Nan
2	Medium	Low	Low
3	Fast	Low	Low
4	Very Fast	Very Low	Cannot Turn
5	Very Fast	Medium	Medium

Observational results for servo modes (5th speed mode)

# Servos Active	Forward Speed	Directional Stability	Turning Stability
3	Fast	Very Low	Cannot Turn
2	Medium	High	Medium
1	No Movement	Nan	Nan

Conclusions

Due to mass balance issues, the robot did not behave well enough to obtain useful quantitative data from the gyroscope. This data was taken from video observations of the robot performance tests. From these results, we have concluded that a higher tail frequency and amplitude along with more tail flexibility is optimal for better maneuverability.

References/Acknowledgements

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