Design Optimization, Experiment Design, Data Collection, and Analysis

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Goal

The purpose of this assignment was to optimize a parameter through validating results in experimentation. This document explains the process utilized to test how different angles of the spine motion affects overall craft velocity. The goal was to maximize the velocity of the bio-inspired salamander robot using different body movements.

Process

The range of motion for the spine will affect the angle of the legs on the granular media, therefore affecting forward thrust and velocity. The actual angle for the spine vs speed of the system will be experimentally tested using the final prototype. The different angles will be specified and achieved using the positional servo motors and the motor controller. In order to test these values, the final prototype had to be constructed. Throughout the final manufacturing process, many problems arose such as methods to actually mount servos and other hardware. This caused many delays in the steps leading to getting the final system together, but after redoing several parts, the prototype was successfully built. Different angles for the spine were experimentally tested. These results were obtained by experimentally testing in quikrete silica sand and using motion capture color-tracking to track the velocity of the craft.

Building the Final Prototype

Final design was laser cut out using cardstock paper, adhesive, and plastic flexure material to create a 5-layer laminate. The three segments of the craft are the front (head), the main body, and the back (tail). Please note that three positions for the servo were designed into the design so in the future, different servo positions can be tested.

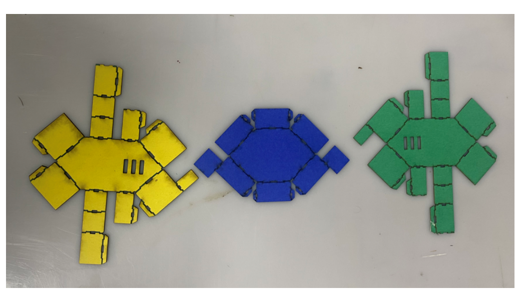

Figure 1. Laminate cut-outs of three segments of body

Then it was put together, using an Arduino and 4 servo motors. Cardboard was used to act as mounting segments for the servos, connecting the servos to the limbs and to the spine. The connection bar creates a 4 bar-linkage and each connection point uses a pin so that the joint is still able to freely rotate.

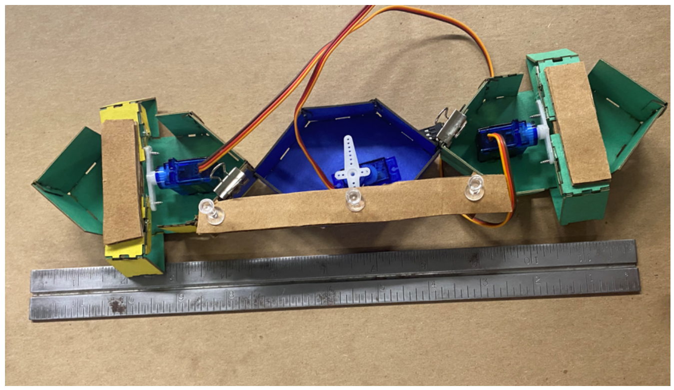

Figure 2. Full body of craft

After conducting initial experiments, cardboard “feet” were added to the craft to encourage forward motion instead of sideways motion.

Experimentation

Experiments were conducted in silica sand quikrete. Different angles were specified in Arduino to be sent to the servo. The servos had a range of 0-180 degrees; however the actual angle of the spine was not equivalent to the input angle. Three different angles were tested with the same oscillation time of .5 seconds between states. The head and tail were independently actuated so that the system can create a c-shape with its body which is similar to the motion that a salamander does on hard surfaces/granular media.

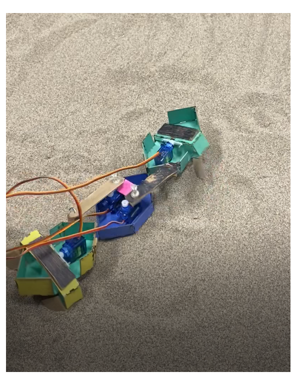

Figure 3. Screenshot of craft in action in silica sand

Results

There was a limit to the angle the spine could achieve due to the design implemented and the hardware selected since servos could only rotate from 0-180 degrees. The results were as follows:

Angle output (deg)	Angle input (servo, deg)	Average Velocity
30	180	1.1265 cm/s
27	160	1.4478 cm/s
24	140	0.42 cm/s