Bio-inspired Robot Technical Report

Barry Brookins
Illinois Institute of Technology
Chicago, Illinois
bbrookins1@hawk.iit.edu

***Abstract*—This report details the design process used to construct a bio-inspired climbing robot. The robot was made of 1/8 in. medium density fiberboard, continuous servos, an arduino board, a breadboard, a 9V battery, and a battery pack. Two sketches of robot designs that would climb a wall, with pegs in it, were drawn, and were based on two different animals. For each of the designs, gait plots, which displayed the movement of the robot, were drawn. Convex contact polygons were analyzed to ensure that the robot would be statically stable throughout its climb. Free body diagrams were drawn to show that the torque produced by the servos was enough to lift the entire robot. The drawings of the robot were made using AutoDesk Inventor and the parts of the robot were laser cut. The parts of the robot were assembled and the arduino was programmed to have the robot climb up the pegs. The robot didn't climb, due to the servos not being able to lift the robot entirely and part of the robot getting stuck under a peg due to the servos being out of sync.**

I. Introduction

A bio-inspired robot was constructed and this report details the design process. It had to meet the following functional requirements: autonomously climbs up an 8ft pegboard wall, is bio-inspired, and has the ability to be disassembled. The robot is shown in Figure 1. This paper will explain each step taken in the design process of the robot.

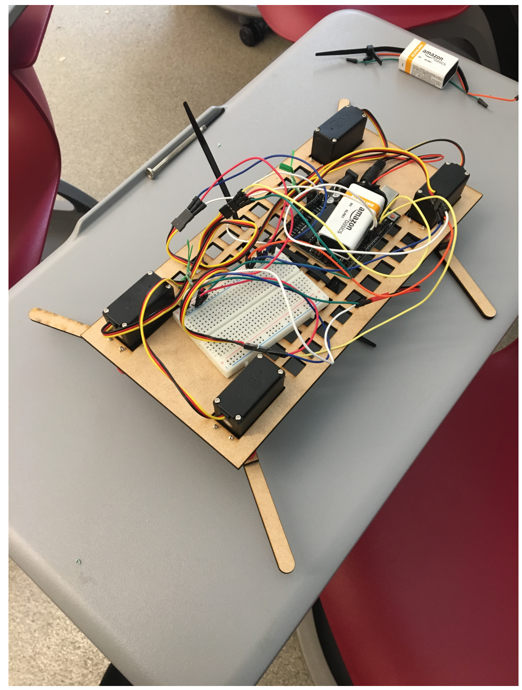


Fig. 1. Final Robot

II. Concept Generation and Evaluation

A. Design Selection

The two animals used to generate designs were a sloth and a dung beetle. The sketches of these designs are shown in Figures 2–3. The first design was created but the robot turned out to be much heavier than expected and its center of mass was too far back in the sagittal plane. The second design was constructed and it was more likely to climb up the wall than the first one, mostly because it was lighter and its center of mass was closer to the center of the robot.

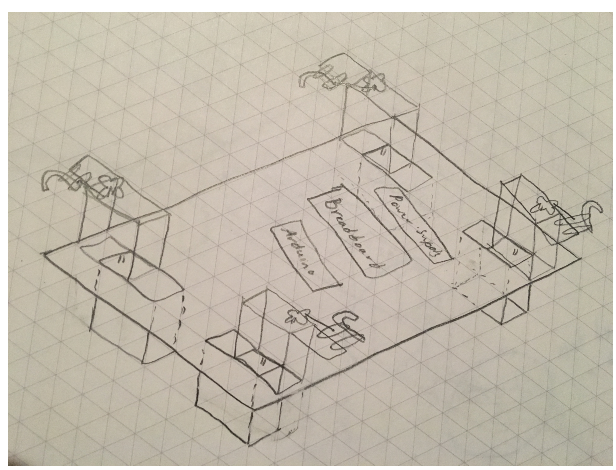


Fig. 2. The Sketch Inspired by a Sloth.

III. Analysis

A. Analyzing Static Stability and Torque Requirements

The gait plots of designs 1 and 2, respectively, are shown in Figures 4 and 5. For the sloth design, at least three servos are holding the robot in place at all times and for the beetle design there are only two servos keeping the robot stable. The convex contact polygon for each section of the gait plot for the designs are shown in Figure 6. Since the robots center of mass is within the contact polygon at all times for both designs, the robot should be stable at each position on the peg board.

The free body diagrams and calculations for the minimum torques needed to keep the robot statically stable throughout

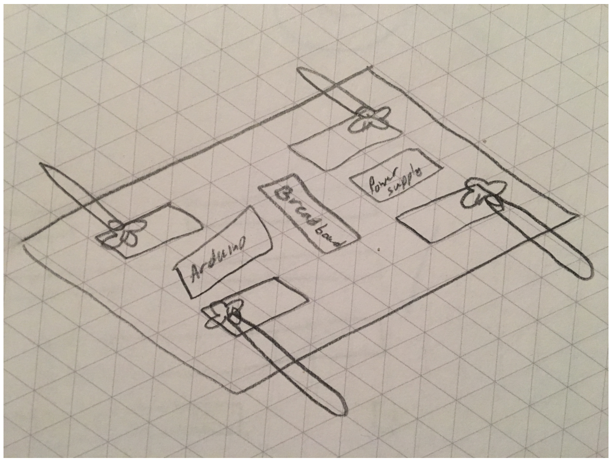


Fig. 3. The Sketch Inspired by a Dung Beetle.

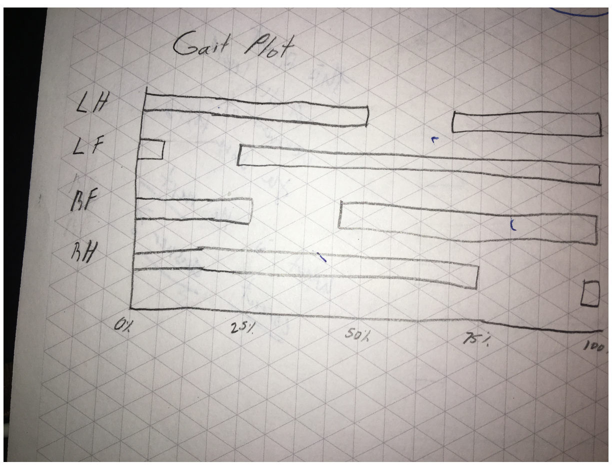


Fig. 4. Gait Plot for Sloth Inspired Design.

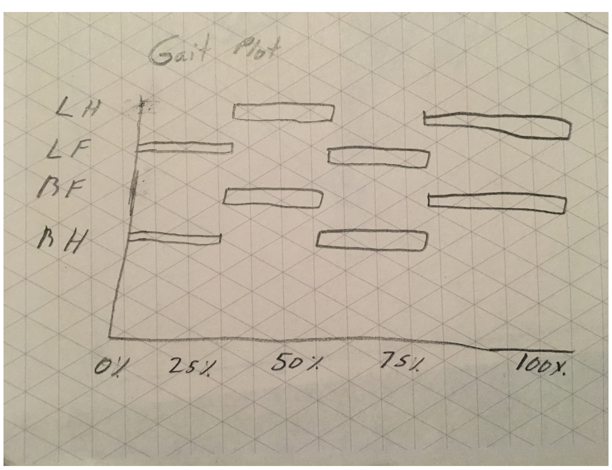


Fig. 5. Gait Plot for Dung Beetle Inspired Design.

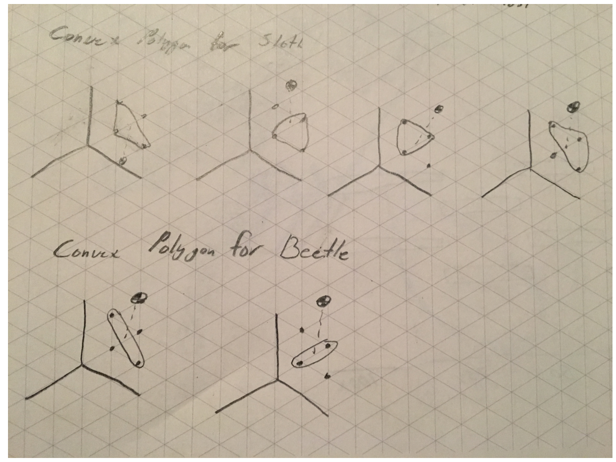


Fig. 6. Convex Contact Polygons for Both Designs.

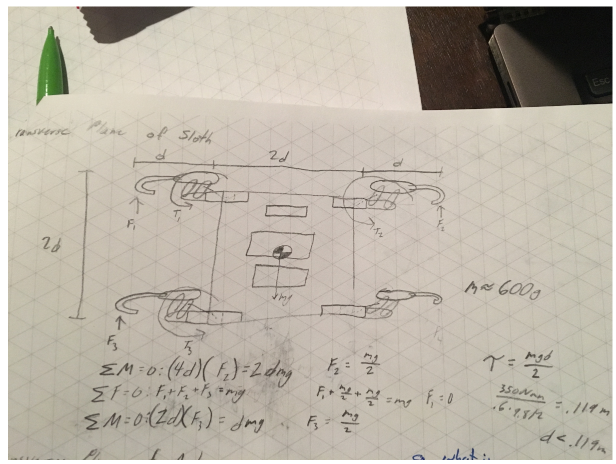


Fig. 7. Free Body Diagram for Sloth Inspired Design.

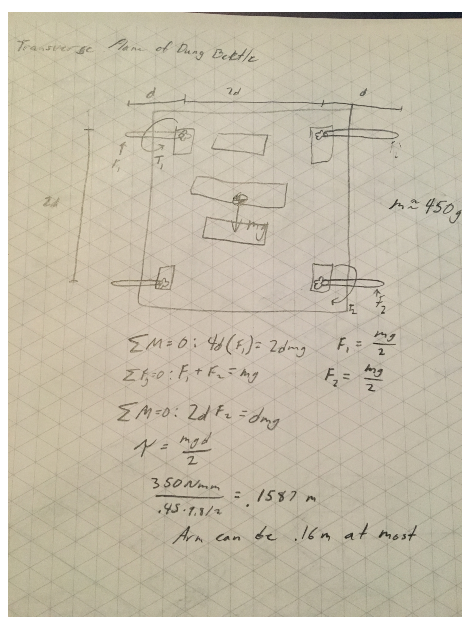


Fig. 8. Free Body Diagram for Dung Beetle Inspired Design.

its climb are shown in 7 and 8. These figures show the analysis of the static equilibrium of transverse plane of the two designs using the three following equations:

$$\Sigma \mathbf{M} = \mathbf{r} \times \mathbf{F} = 0 \tag{1}$$

$$\Sigma F_x = 0 \tag{2}$$

$$\Sigma F_y = 0 \tag{3}$$

where M is the moment about a point, r is the position vector, F is the force vector, F_x is the forces in the x-direction, and F_y is the forces in the y-direction. The approximated weight for the sloth design was about 600g so, using the equations of static equilibrium, the maximum arm length of the robot was .119m in order for the servos to lift the robot. The approximated weight for the beetle design was about 450g so the maximum arm length was about .159m.

IV. Experimental Results

A. Getting the Robot to Climb

When the robot was fully assembled, the code for the arduino was written so that the servos on the right side of the robot would rotate clockwise at their maximum speed and the servos on the left side would rotate counter-clockwise. While this design was conceptually possible, problems with the servos' positions becoming out of sync and the top edge of the robot getting stuck under the peg caused the robot to not climb the wall.

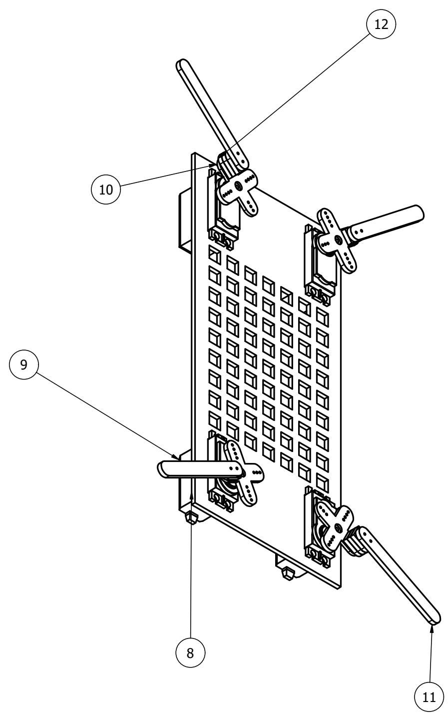
V. Discussion

A. Analysis of Final Product

The bio-inspired design process was used by modeling the motion of the robot after actual animals that climb, such as a sloth and a dung beetle. When designing the robot, it was initially expected to use position servos instead of continuous servos, since continuous servos get out of sync after a while. The arms of the robot were too long to use position servos so continuous servos had to be used instead. This caused one side of the robot to get stuck under a peg when it tried to climb up, which was the main factor in preventing it from climbing.

VI. Conclusion

The construction of this bio-inspired climbing robot better acquainted me with the design process and showed me the difference between an idea working conceptually and an idea that physically works. My robot was unable to climb the peg wall at all, which was not expected before the testing phase. This report was written in LaTeX.



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9	4	aservopart
10	4	servohorn3part
11	4	crank2
12	8	HornSpacer

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CHECKED		
QA		TITLE
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APPROVED		
		SIZE B
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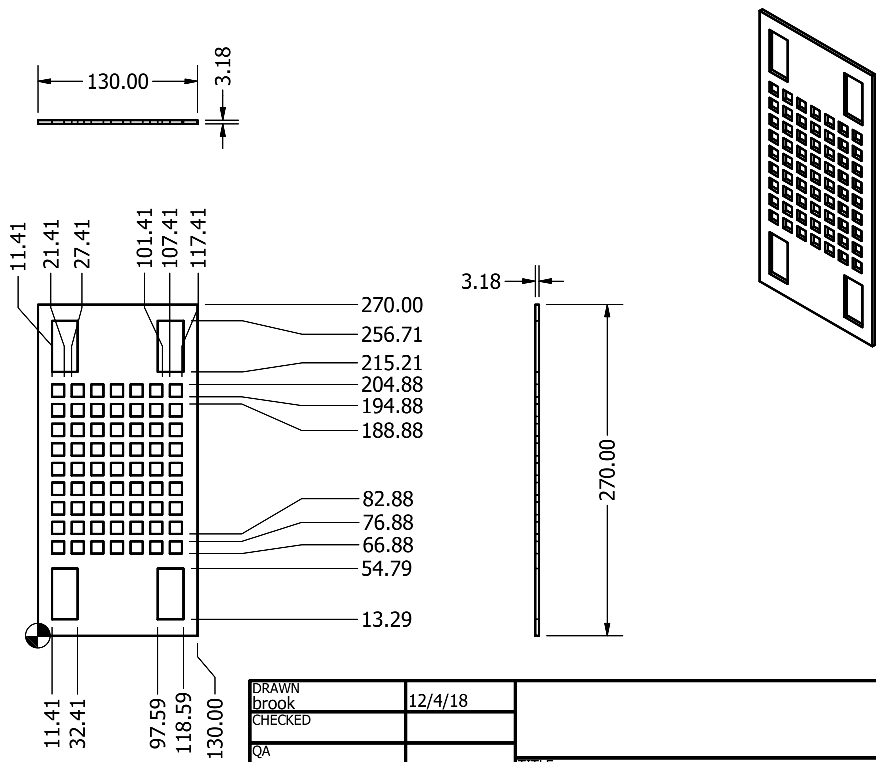

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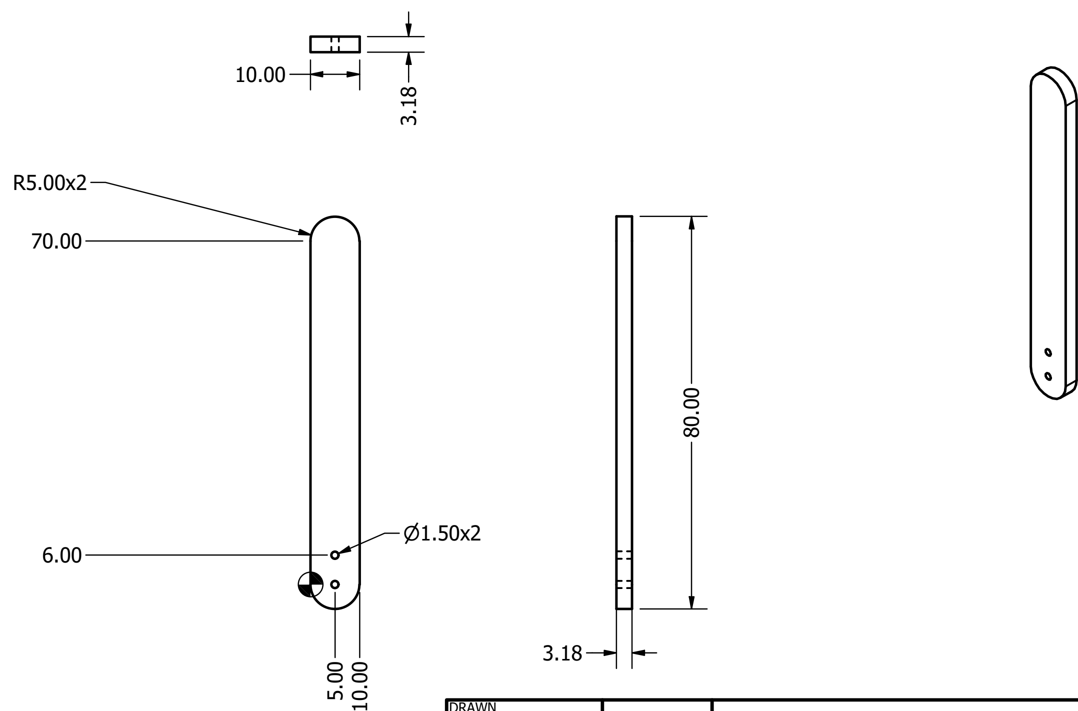

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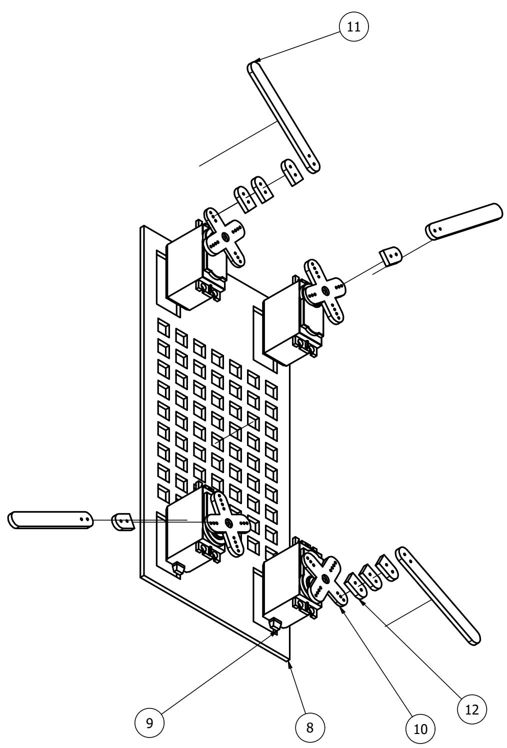

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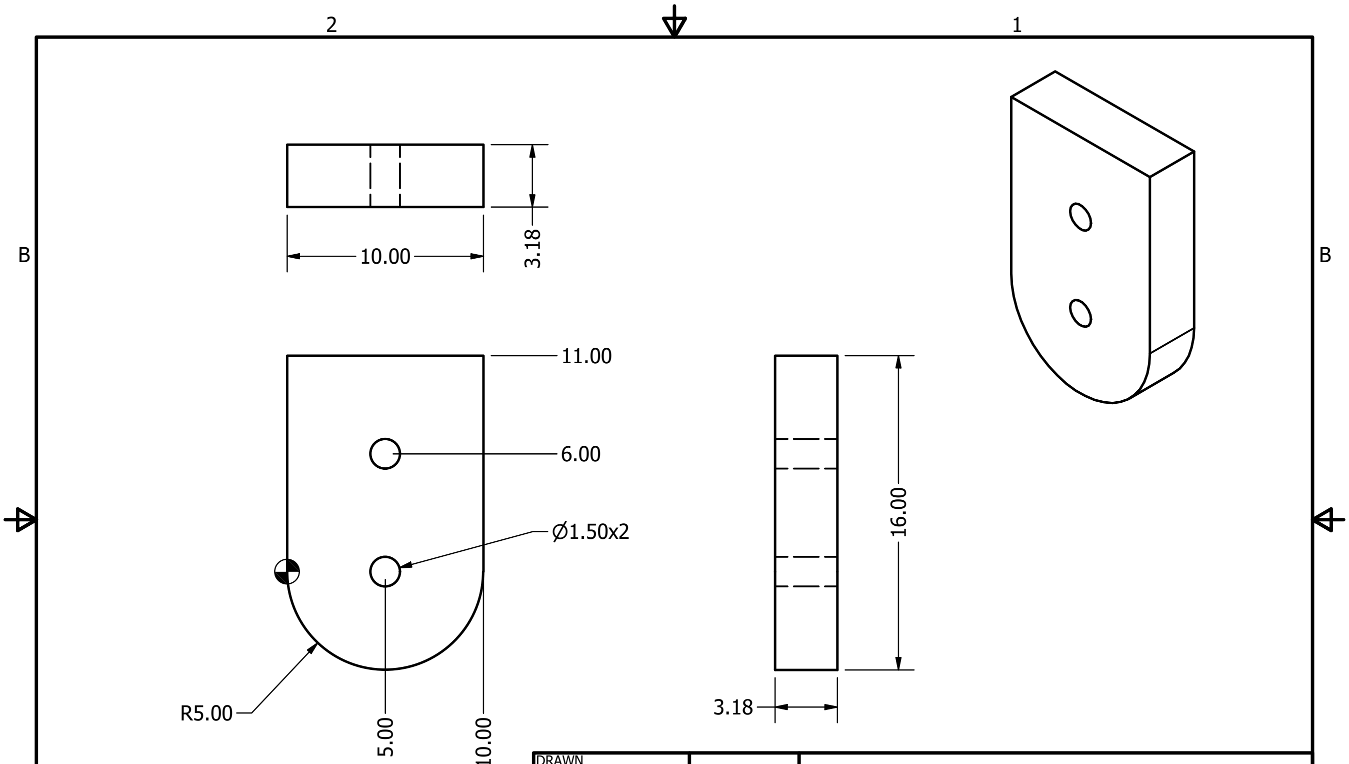

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