Design Optimization, Experimental Design, Data Collection, and Analysis Plan

Viraj Kanchan, Nathan Mayer, Shubang Mukund, Matthew Nolan

Research Question: How can material stiffness of an end effector and the size of the gait affect the overall performance (speed, height, and energy) of a canine-inspired foldable robotic leg?

Student Assigned:	Viraj	Viraj	Matthew	Nathan	Nathan	Shubang
Topic:	Stiffness vs. Speed	Geometry vs Stiffness	Stiffness vs. Height	Gait Size vs. Kinetic Energy of the System	Gait Size vs. Speed	Mass vs. Speed
Design Optimization	X	X	X	X	X	X
Experimental Design	X		X		X	X
Data Collection	X		X		X	X
Data Visualization	X	X	X	X	X	X
Conclusions:	X	X	X	X	X	X

Stiffness vs. Speed: (Average Speed after system has traveled 1m to reach a constant speed) We intend to test the speed of the system (viz the single leg four wheeled test rig) at a given distance of 1 meter; for different stiffness of the end effector. The edd effector stiffness (which intern is a function of both the geometry and the materials used) would be iterated till a sweet spot is reached wherein the speed is maximized while maintaining the required rigidity.

Geometry vs Stiffness: (Bending stiffness for different geometries)
This experiment would be a software based DOE (Design of Experimentation) exercise. Utilizing the DOE tool in solidworks the geometry of the end effector would be optimized by maximizing the bending stiffness while minimizing the weight.

Stiffness vs. Height: (Height that the system can lift the front of the testing rig)
We will use scipy.optimize.minimize() to find the ideal stiffness of the end-effector link that maximizes the height the top of the mechanism achieves on each gait cycle in the simulation (within a reasonable set of stiffnesses). We'll then adjust the stiffness of the end effector to match as closely as possible to the model in an attempt to validate the simulation. Data will be collected using a smartphone camera and motion tracking software.

Gait Size vs. Kinetic Energy of the System: The gait size as described by our previous biomimetic research, will be altered in the overall size of the ellipse created. Therefore, the kinetic energy of the system will be altered based on the actuation of the servos in accordance to the desired gait. All of these experiments will be performed within pynamics in order to solve for the resulting kinetic energy of the system.How does the size of the gait followed by the end effector of the system affect the overall kinetic energy of the system? Does a larger overall kinetic energy have a positive or negative effect on the overall performance and speed of the system?

Gait Size vs. Speed: Similar to the previous experiments, the team aims to test the gait size as it relates to the overall speed of the physical prototype.These tests will be performed by altering the control algorithm of the servos in the physical model to change the end effector path. The speed will then be tracked using motion tracking software and the data collected will be analyzed in Python. How does the size of the gait followed by the end effector of the robot affect the speed achieved by the system? How does the speed of actuation in the servos need to be altered to match the speed of the overall system for different gaits?

Mass vs. Speed: (Adjusting the mass on the testing rig to reduce or add mass onto the robotic leg)
Just like the 1st experiment we will be testing the speed ie the time taken by the system to travel a fixed distance of 1m; the variable in this case would be the total mass of the system. In order to make good contact and have a normal gait cycle it's important that the ratio between the sprung and the unsprung mass be maintained at a sweet spot. Therefore in this experiment we intend to add weights to the entire system and see it's effect on the time taken for it to cover the distance of 1m. We also intend to change the weight bias and see what effect that has on the walking pattern.