Developing a gantry system for a tendon-driven CAT quadruped

Bryant Huang - bryanthuang8@gmail.com, Darío Urbina-Meléndez, Francisco Valero-Cuevas
Gretchen Whitney High School, Class of 2021
USC Viterbi Department of Robotics Engineering, SHINE 2019
Brain-Body Dynamics Lab (BBDL)

SHINE
Summer High School Intensive in Next-Generation Engineering

Introduction

The Valero Lab explores how animal-inspired tendon-driven systems can improve the agility and mobility of robots.

We can better understand how tendon driven systems function by reverse engineering the anatomies of animals.

We do not know much about how to control tendon-driven anatomies but building these robots and conducting experiments can give us a better idea.

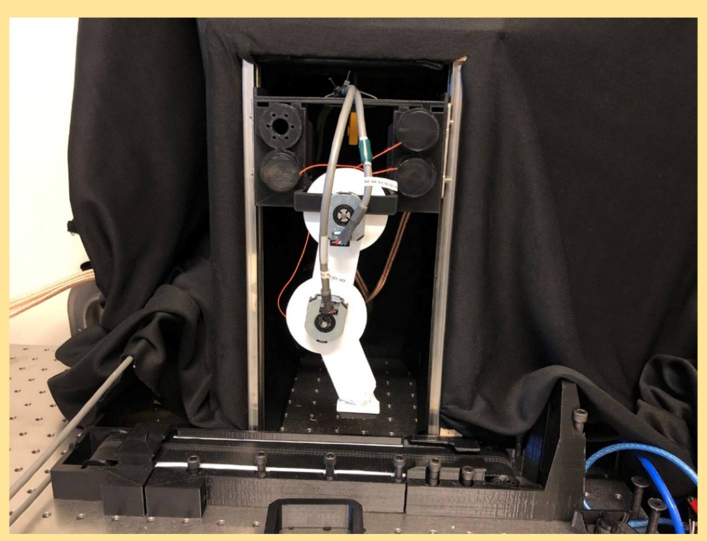


Figure 1: This DC tendon-driven uniped robot was inspiration for the quadruped design. Source: **[Ref 1]**

Objective & Impact of Professor's Research

The end goal is to acquire a better understanding of tendons so that doctors can help patients rehabilitate better.

Our objective was to build external supportive structures like the gantry presented here for Kleo (a tendon-driven CAT quadruped robot actuated by DC motors).

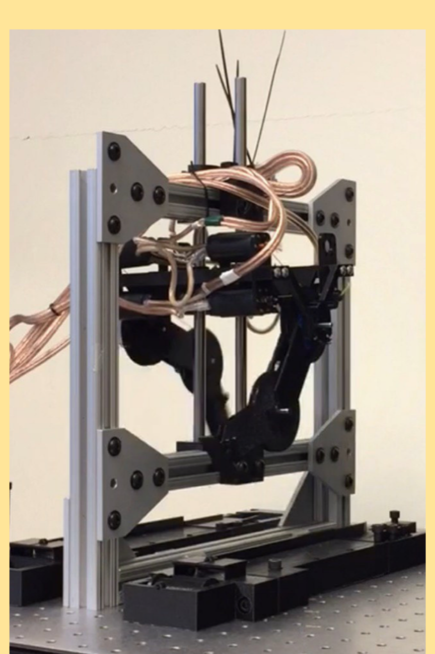


Figure 2: The biped robot with a support structure (Design by Darío Urbina-Meléndez)

Earlier Iterations of the Gantry

V1

- 8020 parts
- Wheels for mobility
- Pulleys hold strings

Figure 3: A render of gantry V1. Design: Bryant Huang (BH)

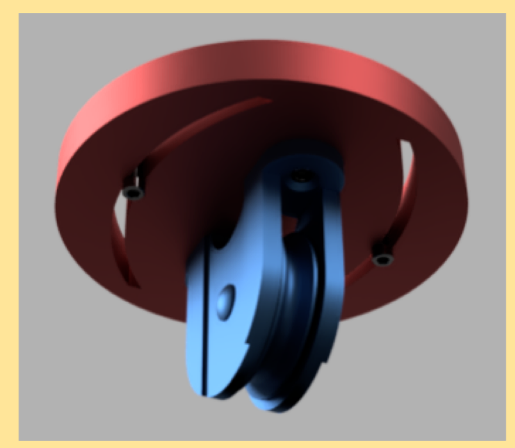


Figure 4: A render of the custom pulley. The string wraps around the pulley and is tied around a connection point on the CAT robot. Design: BH

V2

- Handlebar system for easy control
- Lower top plane is closer to CAT

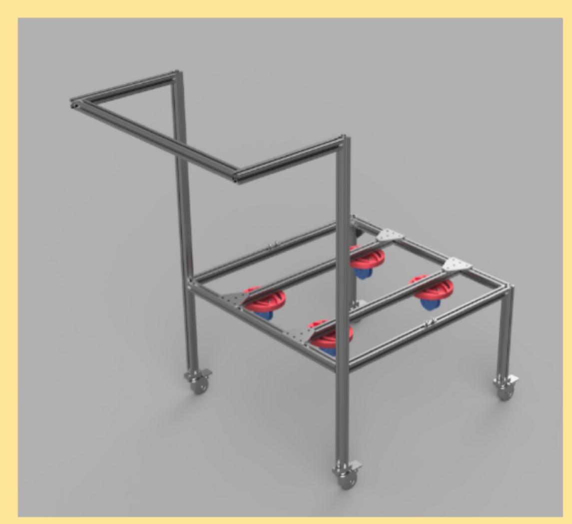


Figure 5: A render of gantry V2. Design: BH

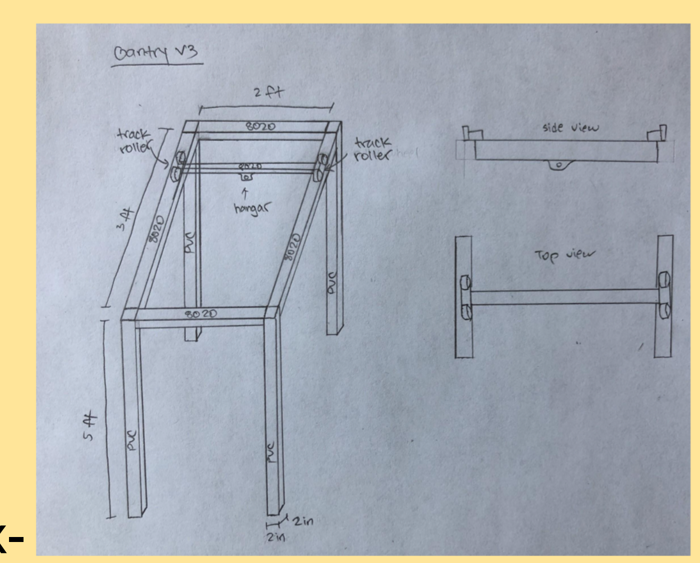


Figure 6: A drawing showing the initial plans for gantry V3. Design: BH

V3

- Stationary gantry
- CAT moves freely in the x-y plane

Figure 7: One of the many iterations of gantry V3. The sliding hangar piece worked well. However, the track rollers could not move freely enough along the two rails to be used in the final design. Design: BH

Final Gantry + Assembly

V4

- 4 feet tall, 3 feet long, 2 feet wide gantry
- Hangar moves freely along x-axis

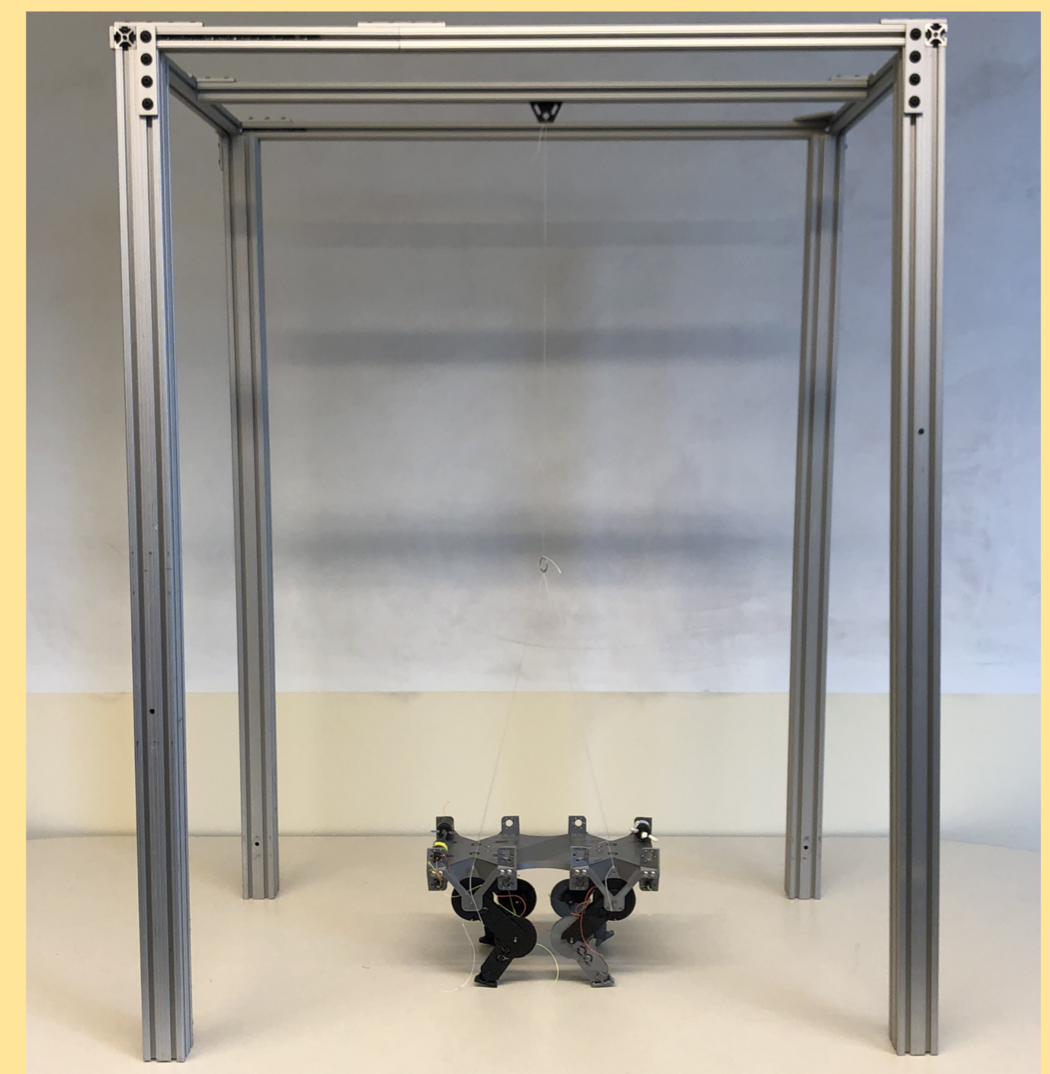
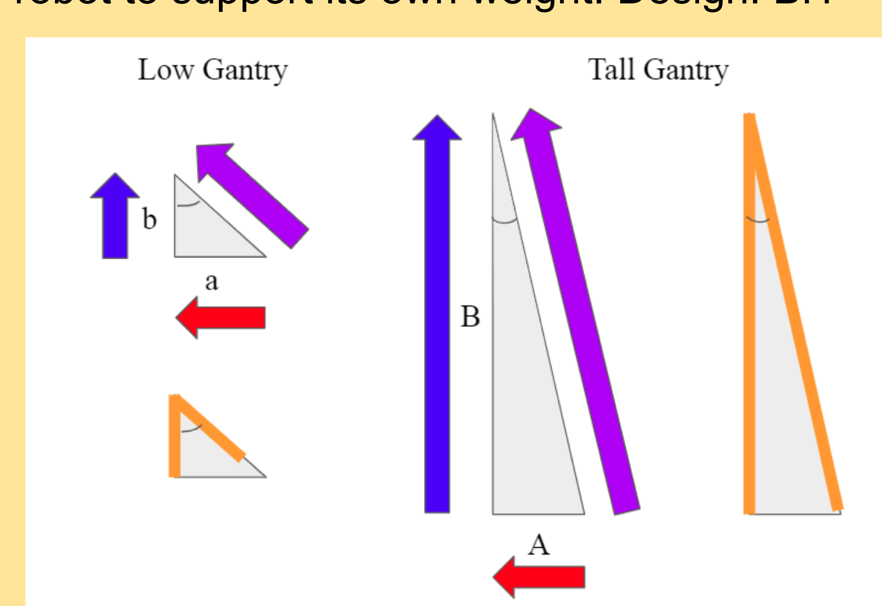


Figure 8 (Above): The final gantry with respect to the CAT robot. The CAT is attached to the sliding hangar on the gantry via strings. Design: BH

Figure 9 (Below): Unlike a low gantry, a tall gantry closely maintains the ideal string length and tension as the CAT robot walks. The equal orange lines compare vertical leg to hypotenuse length. This shows how similar in length the purple and blue forces are for the tall gantry, which is good. The CAT robot also uses less energy to move forward with a tall gantry because the red force, which opposes the CAT's movement, is smaller. This small counter force is negligible and thus makes the gantry mechanically invisible in the x-y direction. All in all, the gantry will mainly help the CAT robot to support its own weight. Design: BH



Skills Learned

Technical Skills

- Fusion 360 (CAD)
- Prusa Slicer (3D printing)
- Google Sheets (Managing finances)

Other lessons

- Team building
- Deliver results
- Iterations are necessary

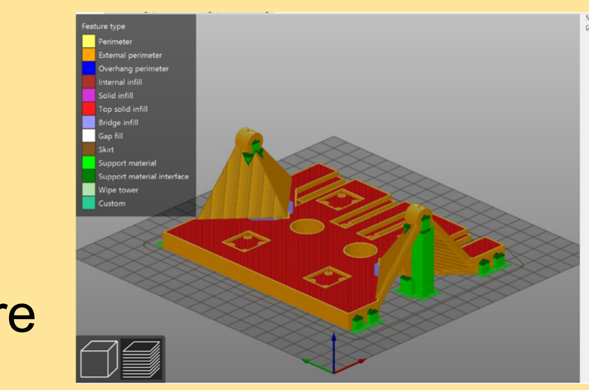


Figure 10: The 3D print preview in Prusa Slicer. PC: BH

How This Relates to Your STEM Coursework

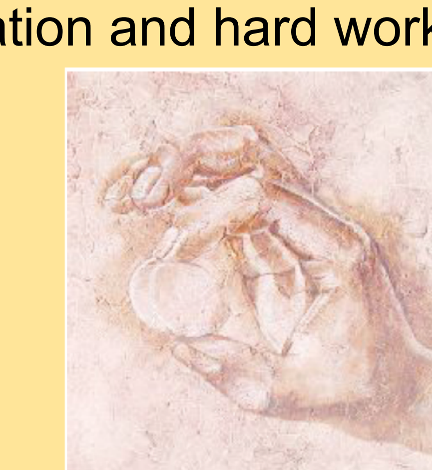
I applied textbook concepts like basic trigonometry, physics, and biology in our design process.

I will bring team building skills back to my extracurricular activities, such as robotics.

Acknowledgements/References

I sincerely thank my lab mate Irie Cooper for always having my back, Dr. Mills, Dr. Herrold, VAST, and the rest of the SHINE team for their dedication and hard work to the program.

Thank you BBDL for being so welcoming patient. I will never forget this amazing learning experience!



Ref 1: Marjaninejad, A., Urbina-Meléndez, D., Cohn, B. A., & Valero-Cuevas, F. J. (2019). Autonomous functional movements in a tendon-driven limb via limited experience. *Nature machine intelligence*, *1*(3), 144.