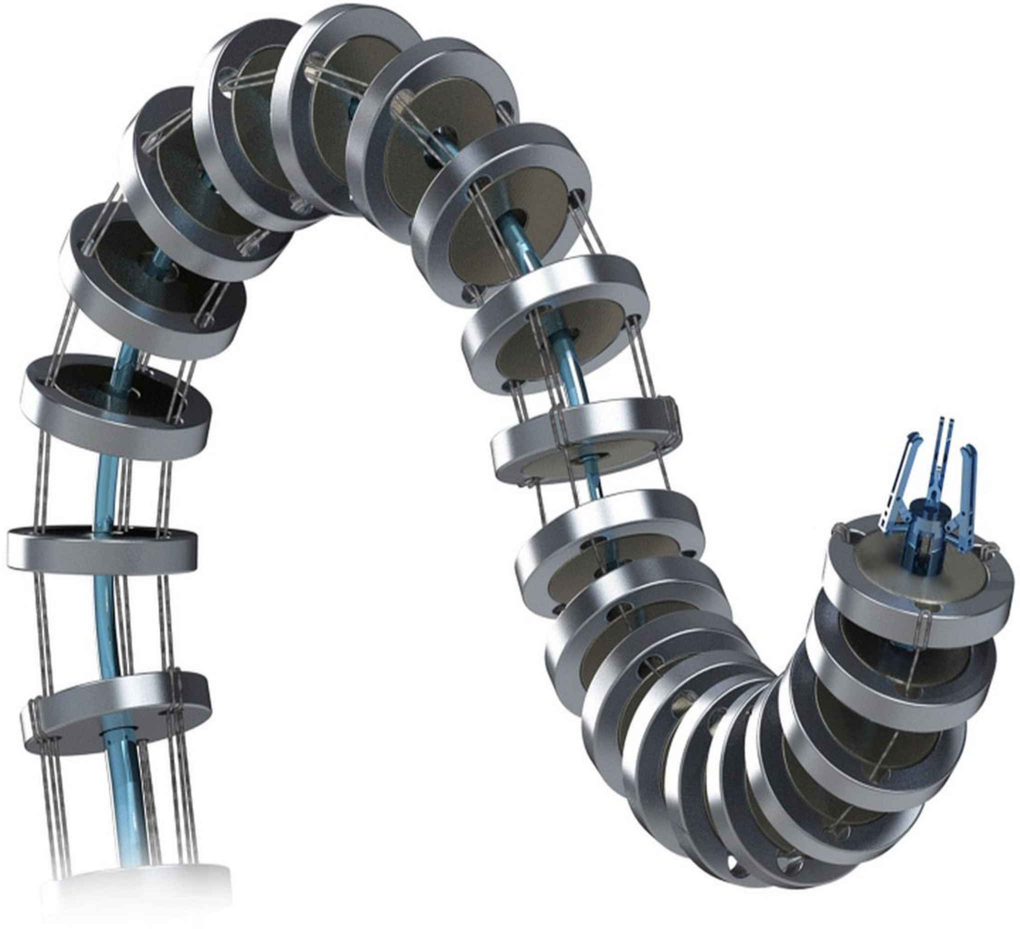
Summer Research Project 2019: Building Long & Thin Continuum Robots

Yannis He

UNIVERSITY OF TORONTO

CRL

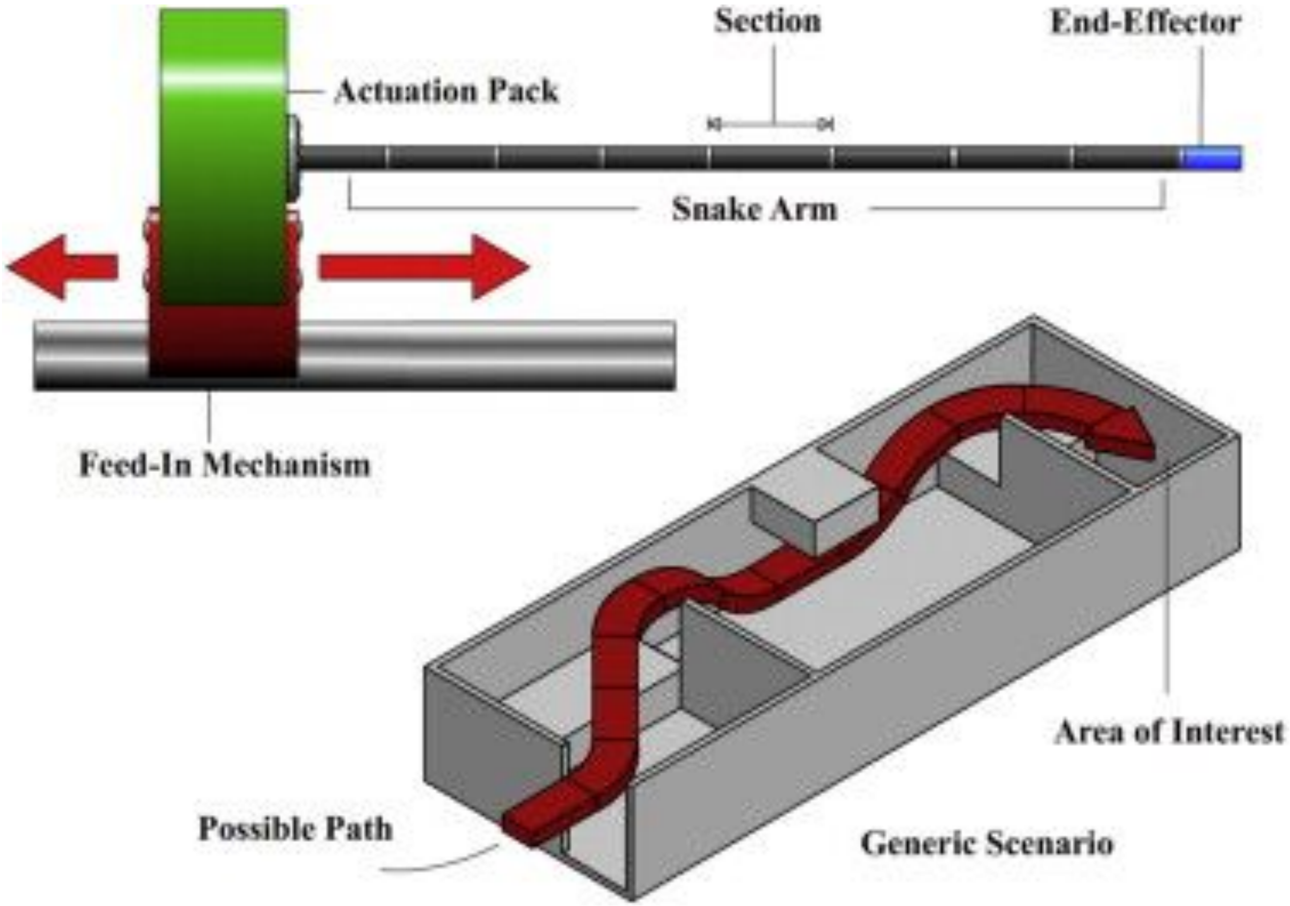
Target:



(Hansen, 2019)

Design a thin, long continuum robot that is ideally 700mm and above in length, as well as less than 10mm in diameter

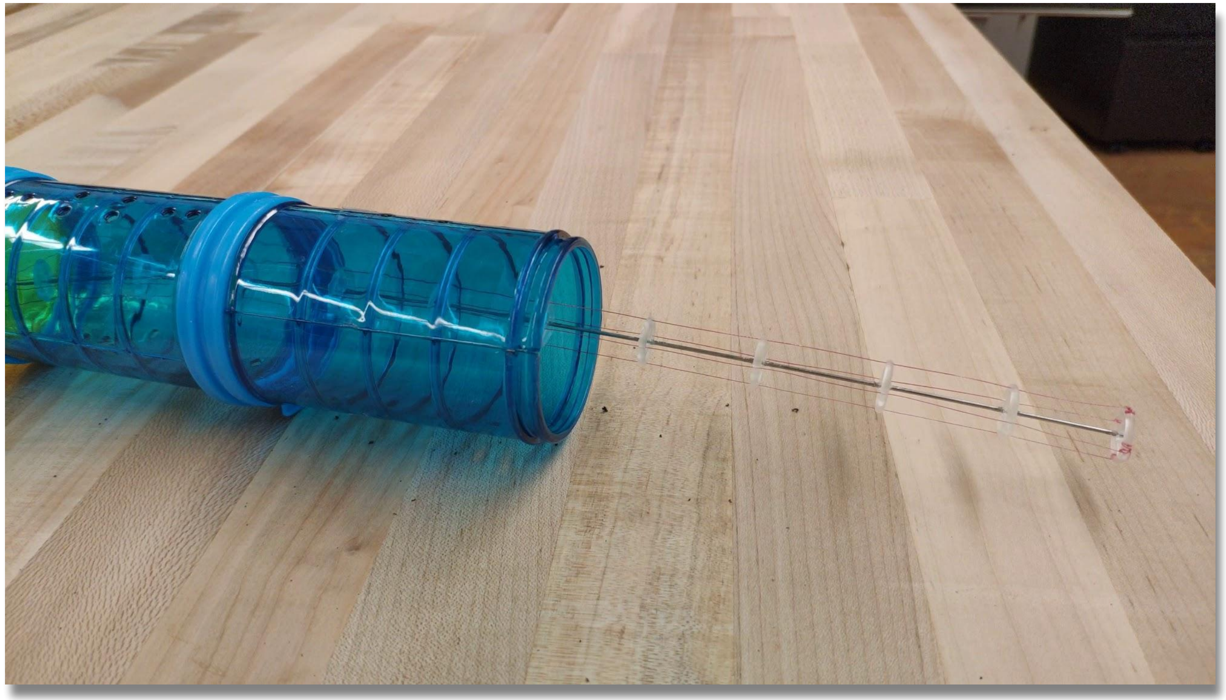
Motivation: Inspection, Navigation, and Rescue

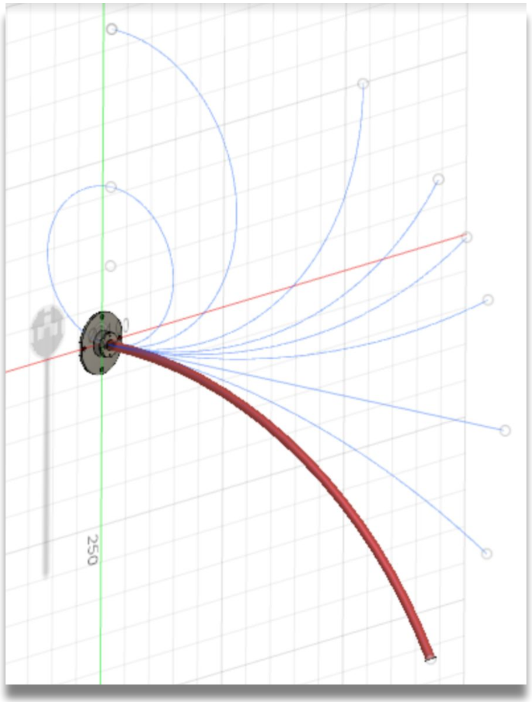


(Palmer, Cobos-Guzman and Axinte, 2014) (Hansen, 2019)

Current States of the Arts

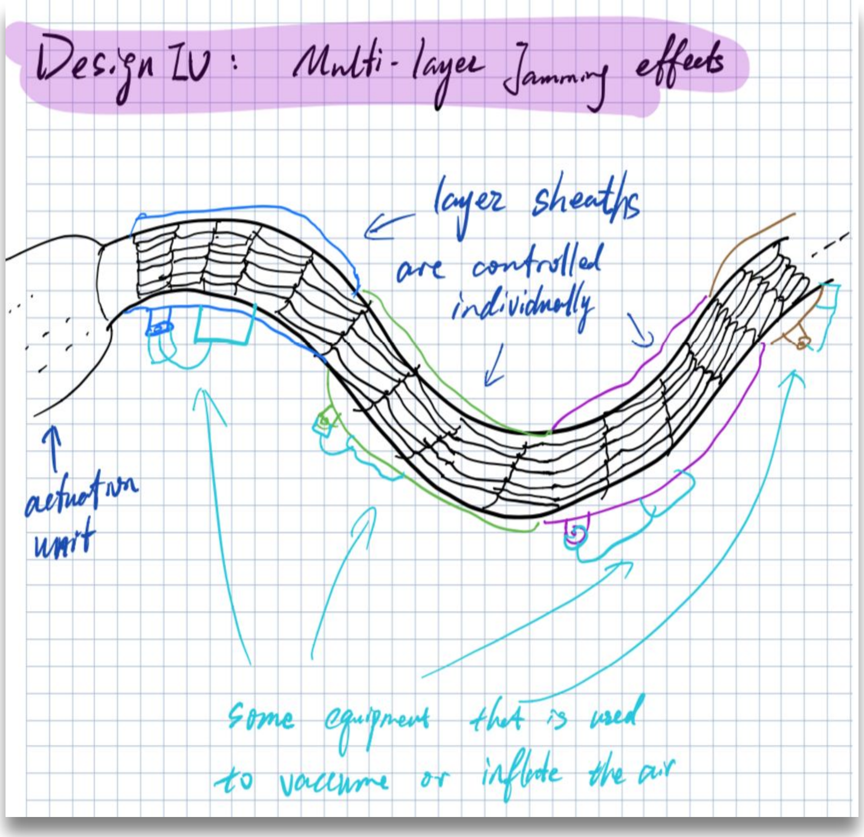
Building a long and thin continuum robot is still a challenge.

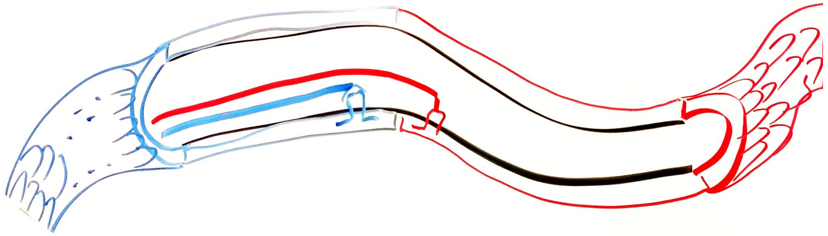


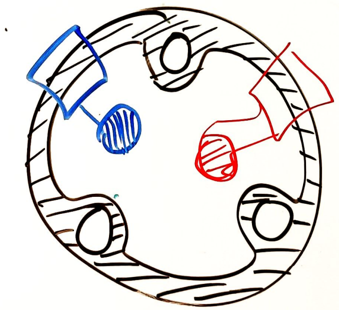


Two Approaches to Overcome the Challenge

Multilayer Jamming Approach:







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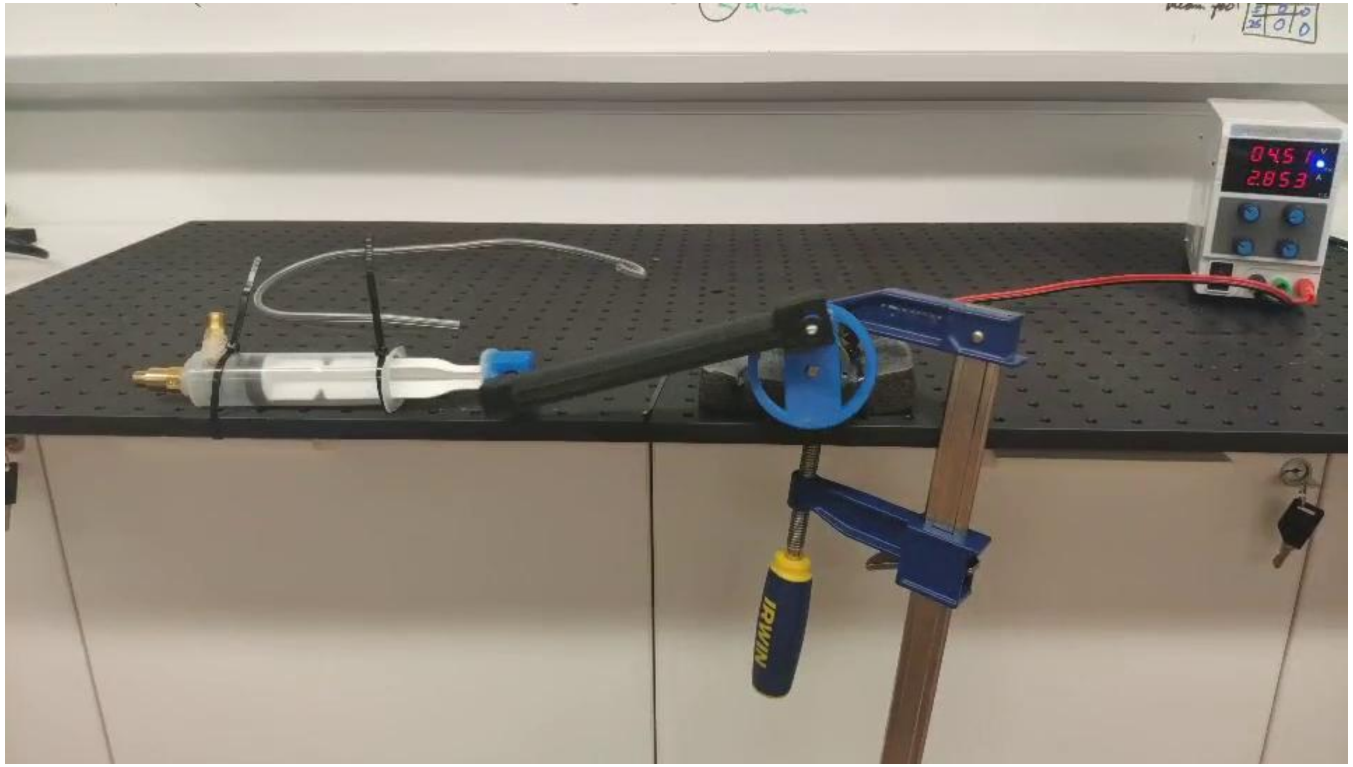

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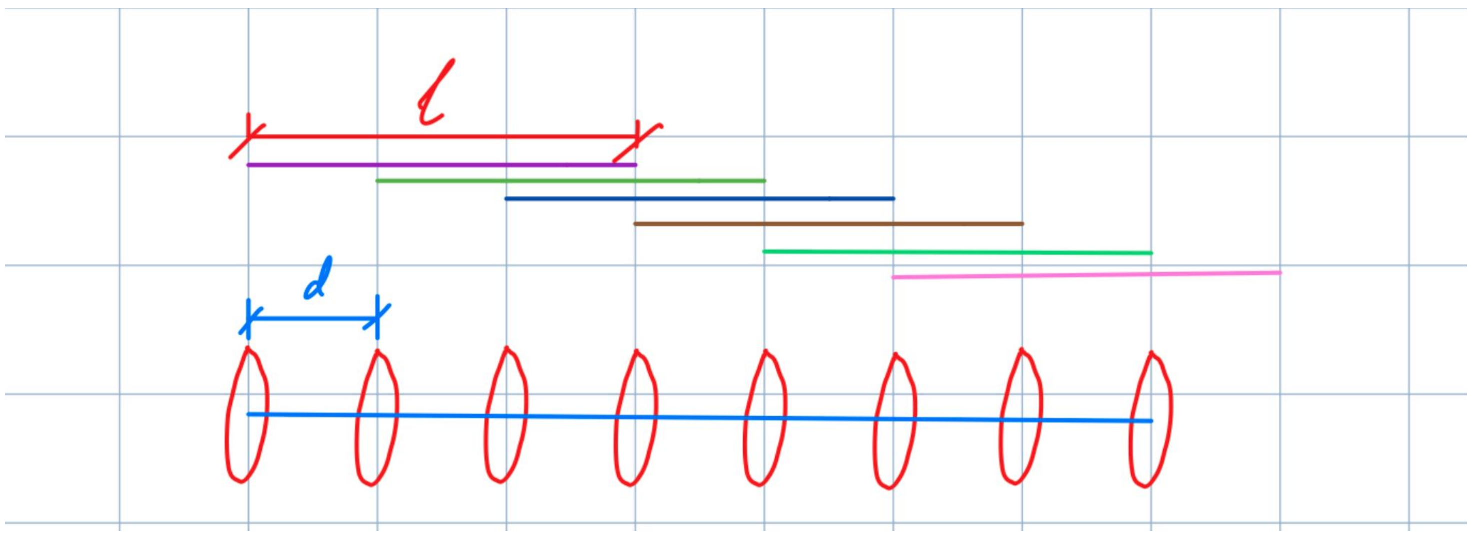
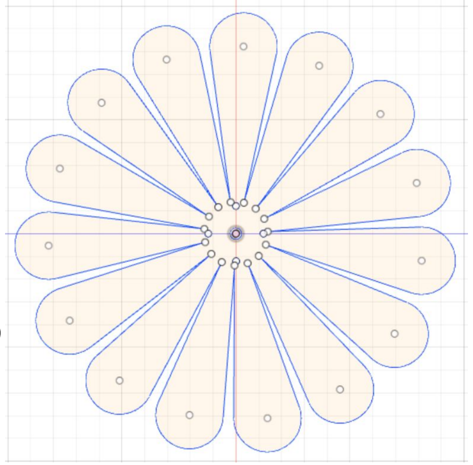
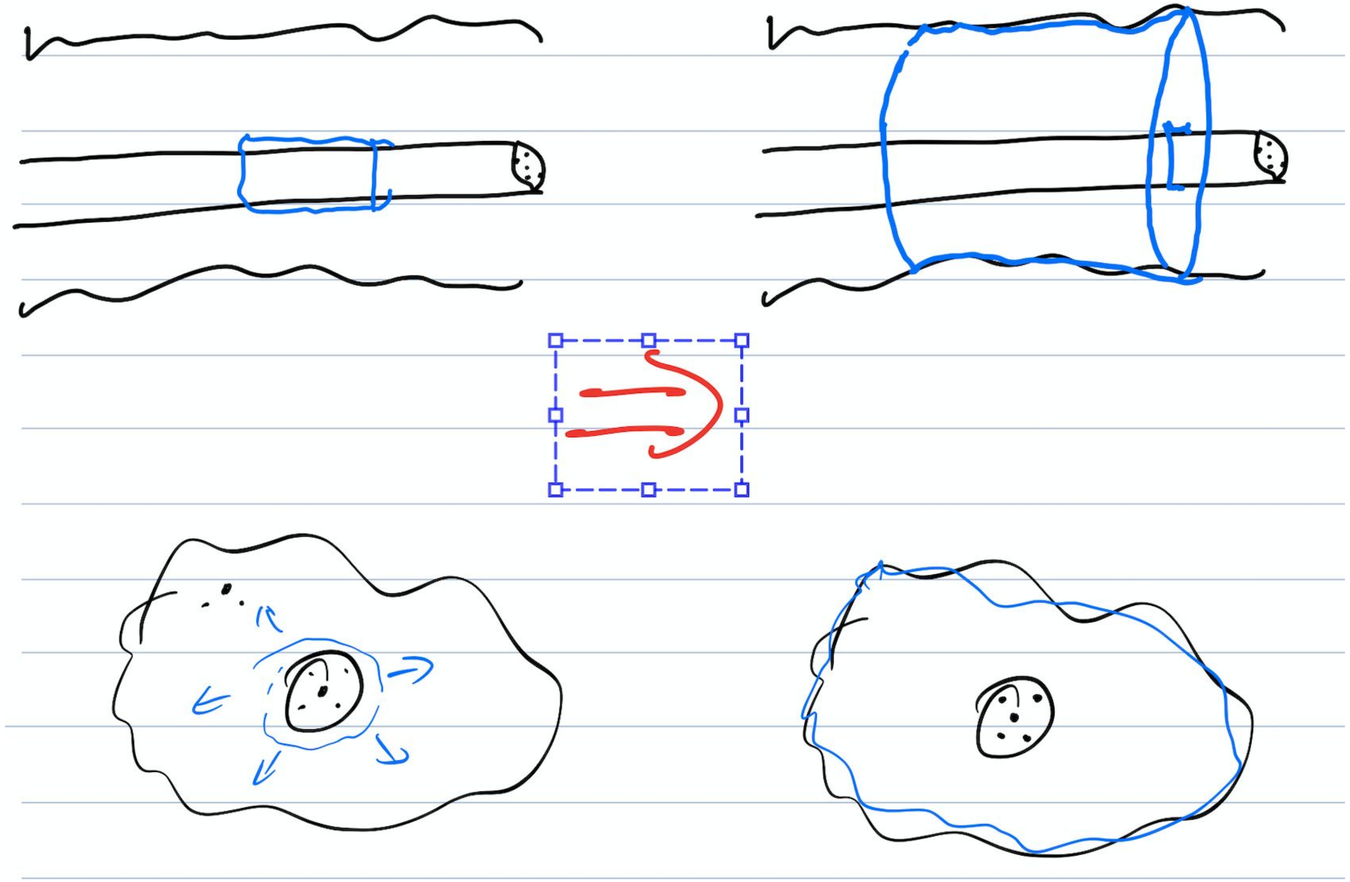




(Idea from Volker, a former CRL Student)

Two Approaches to Overcome the Challenge

Tripod Approach:



Two Approaches to Overcome the Challenge

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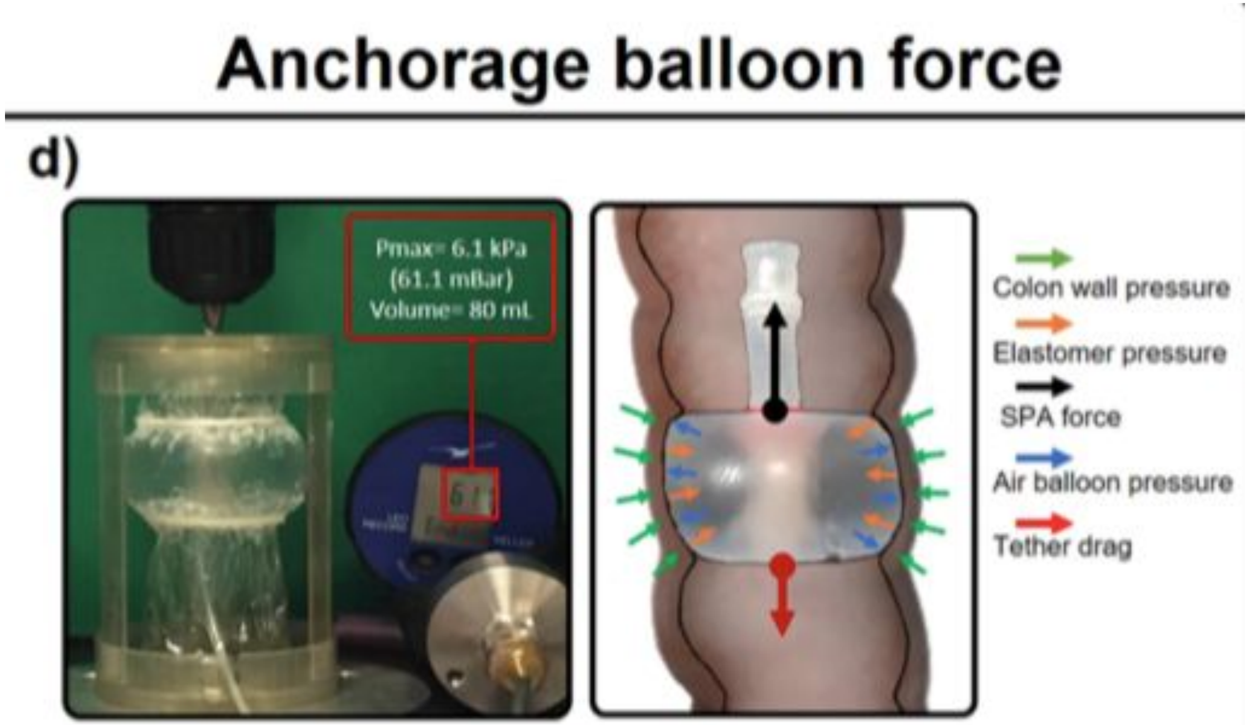


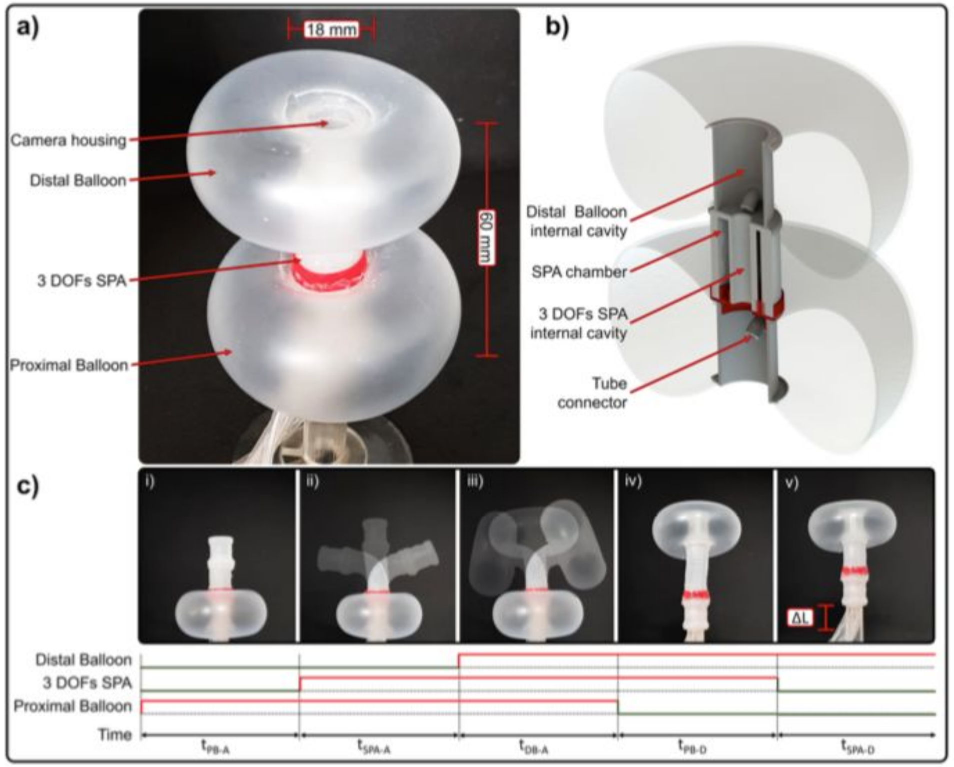
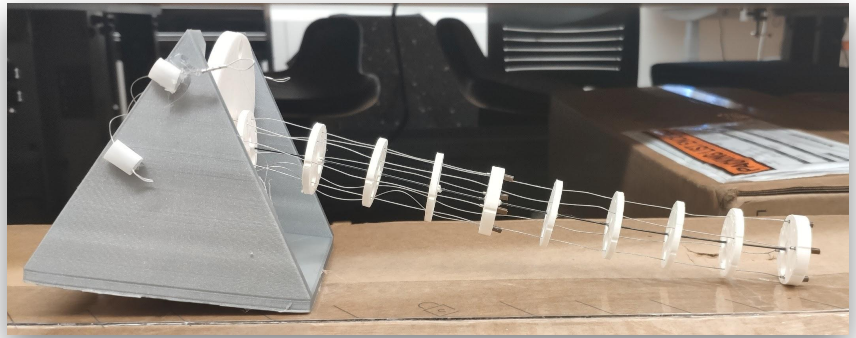
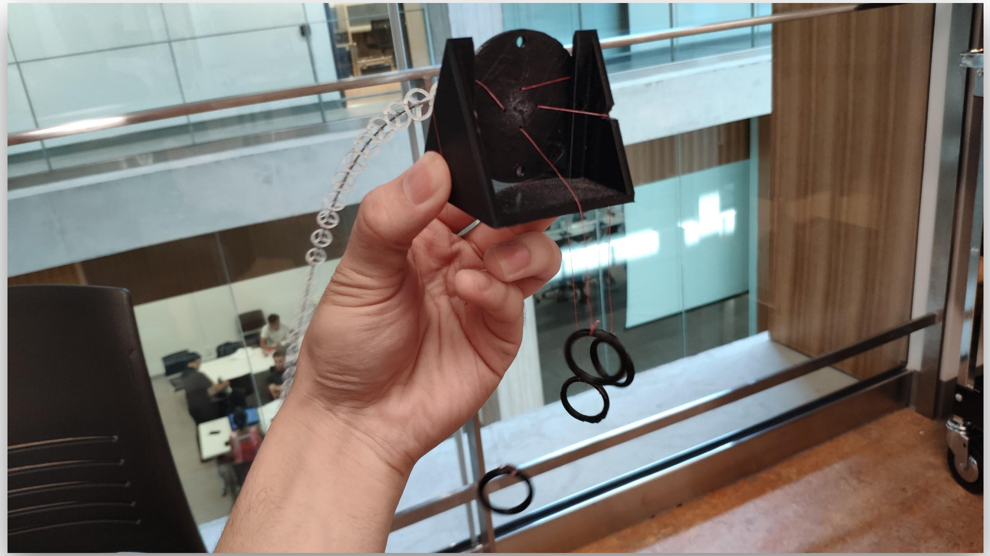


Figure 1. SPID design: (**a**) perspective view with the distal and proximal balloon activated; (**b**) cross-sectional showing the available inner space of the balloons and the SPA; (**c**) five steps bio-inspired locomotion, where (i) t_{PB-A} is the time needed to activate the proximal balloon, (ii) t_{SPA-A} is the time to activate the SPA in line with the orientation of the colonic lumen, (iii) t_{DB-A} is the activation time of the distal balloon providing anchorage, (iv) t_{PB-D} is the deactivation time of the proximal balloon, and (v) t_{SPA-D} is the deactivation time of the SPA to move it forward.

(Manfredi et al., 2019)

Prototyping





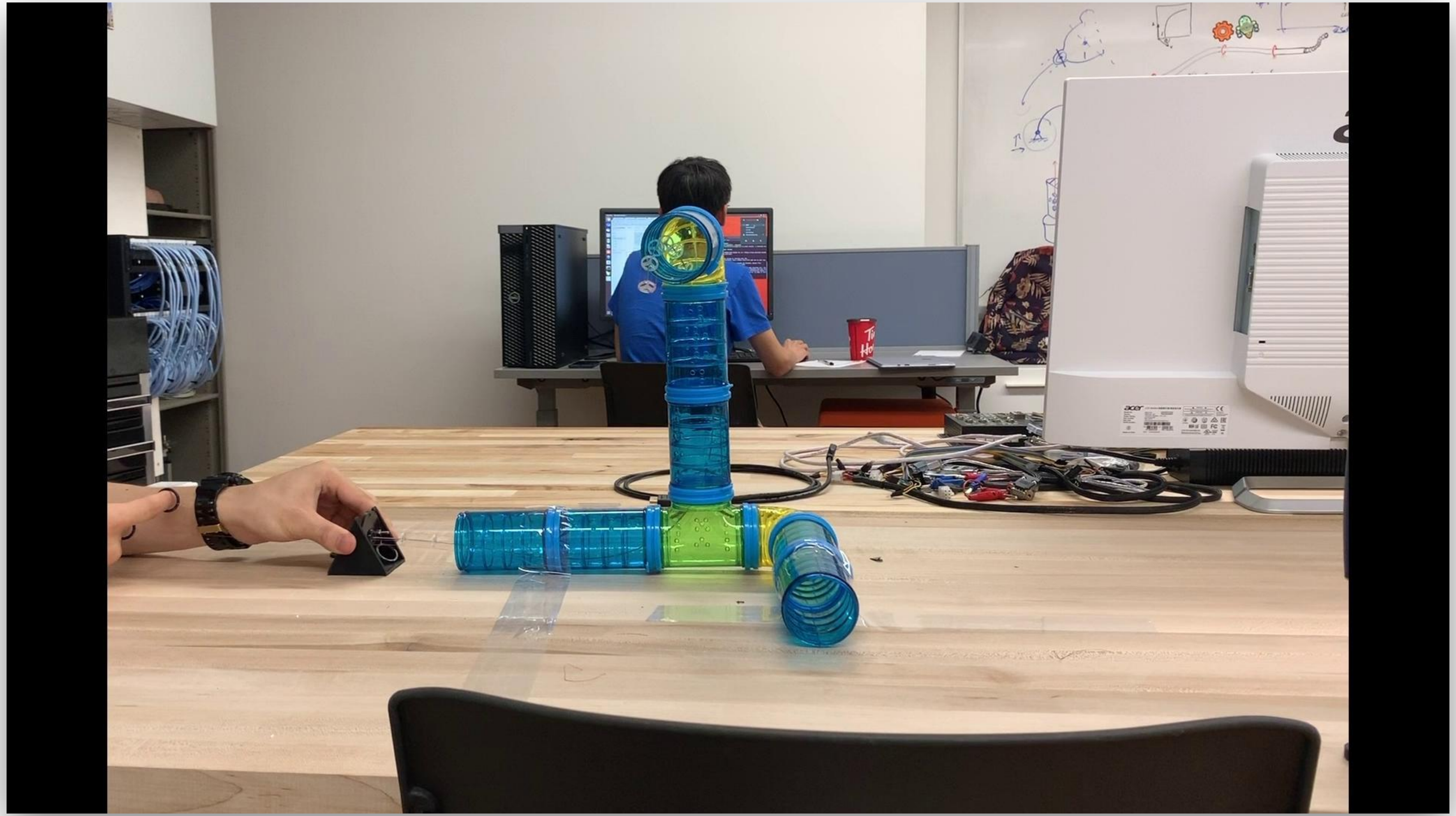
Hamster 1.0

Length: 710mm

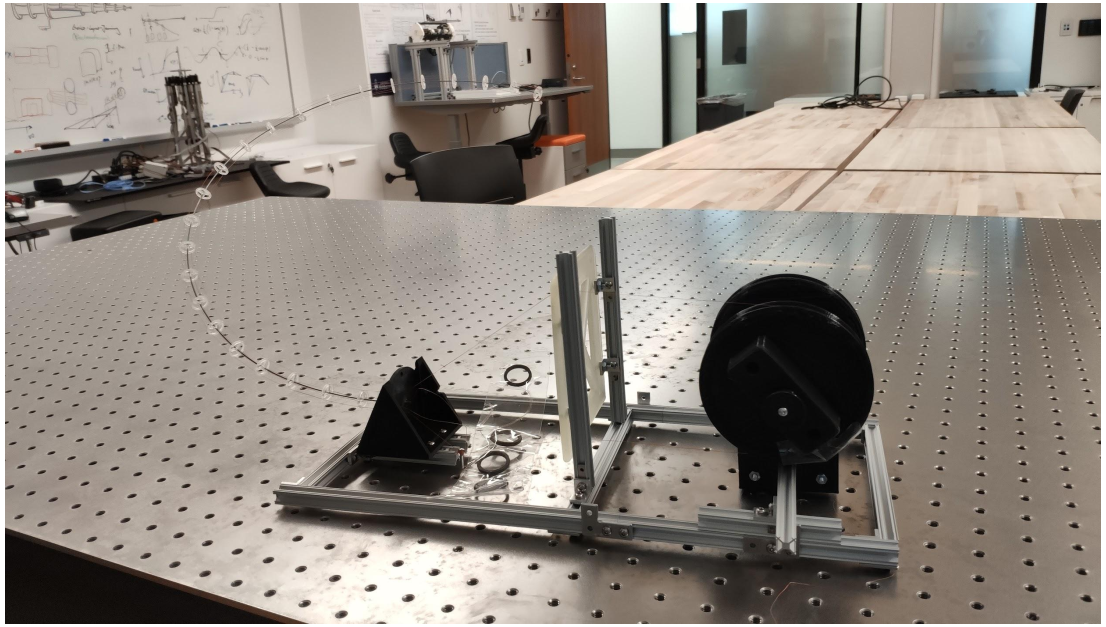
Diameter: 14mm

Unexpected Discovery:

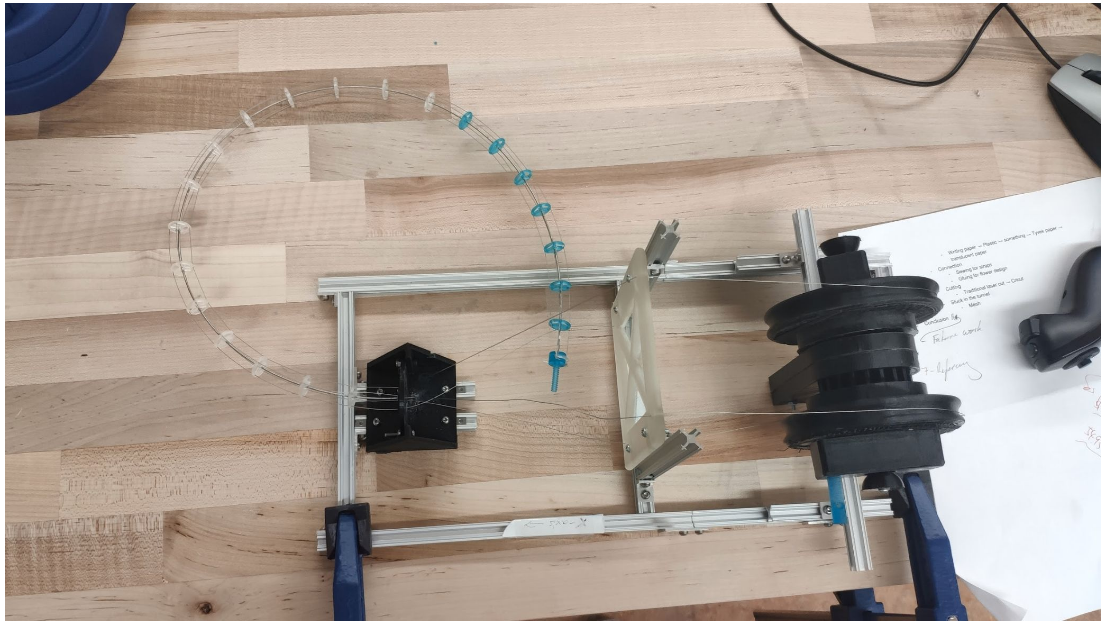
Validation 1 for Navigation



Hamster Series: Designed for Testing



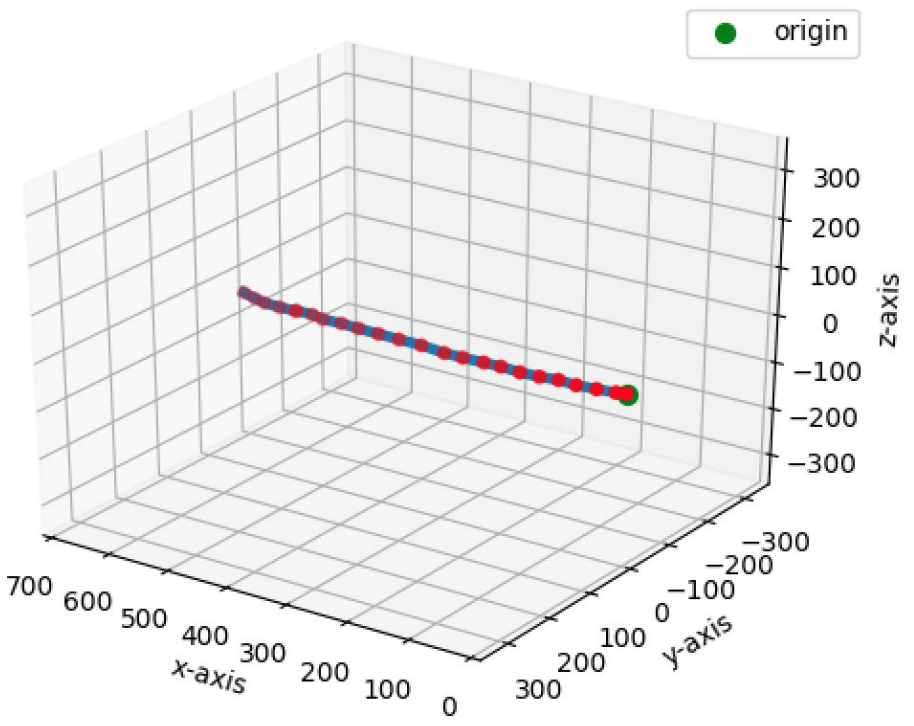
Hamster 2.0

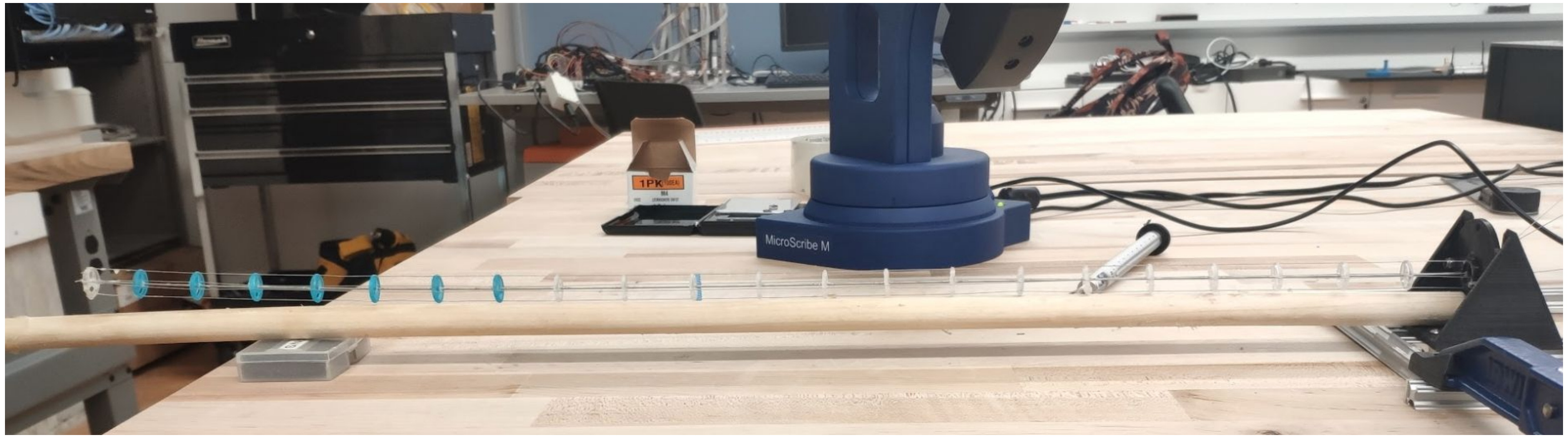


Hamster 2.5

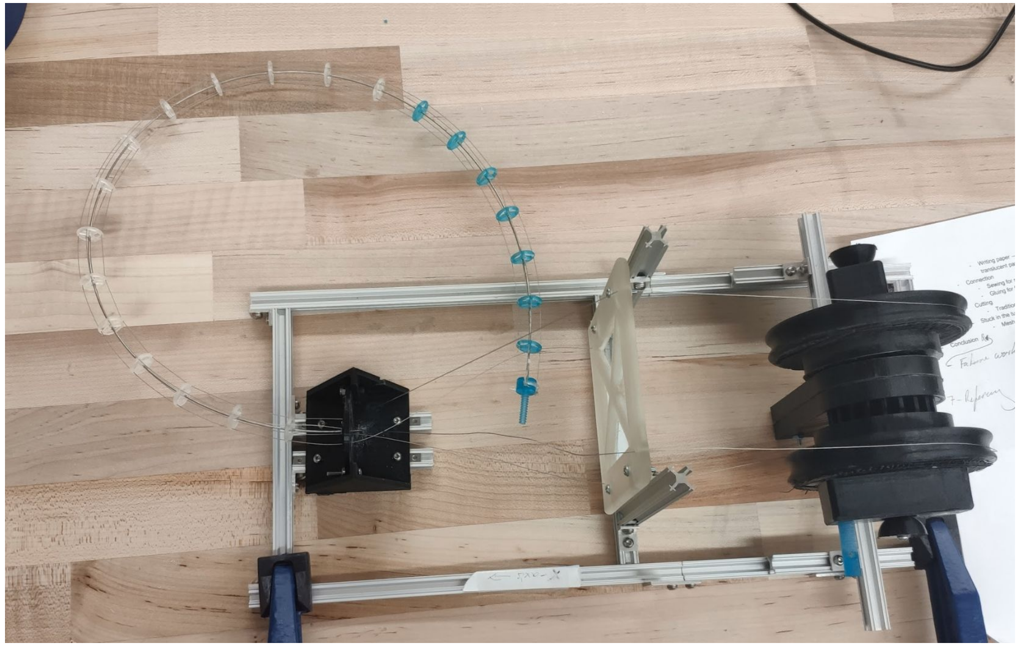
Both position can be locked

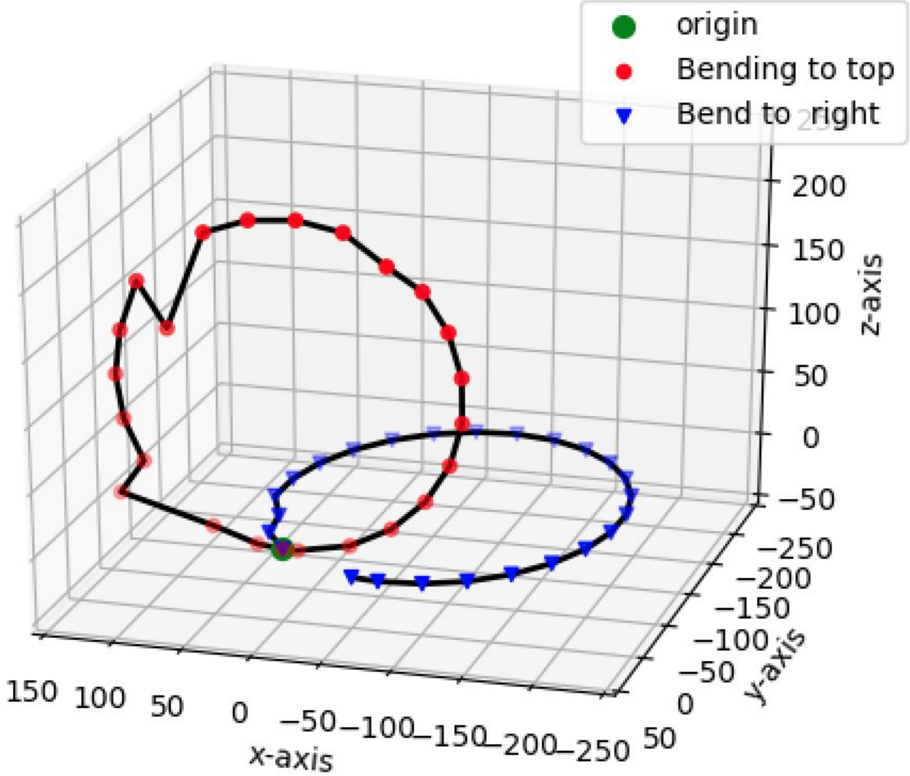
Measurement 2: Initial Position





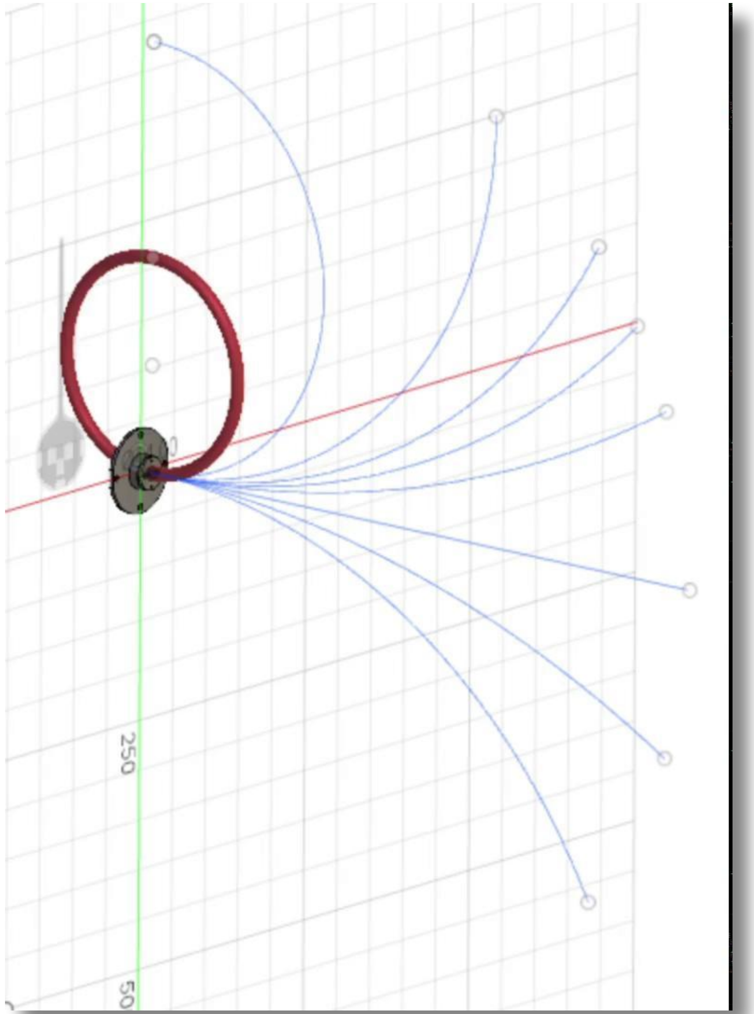
Measurement 3: Extreme Bending Position

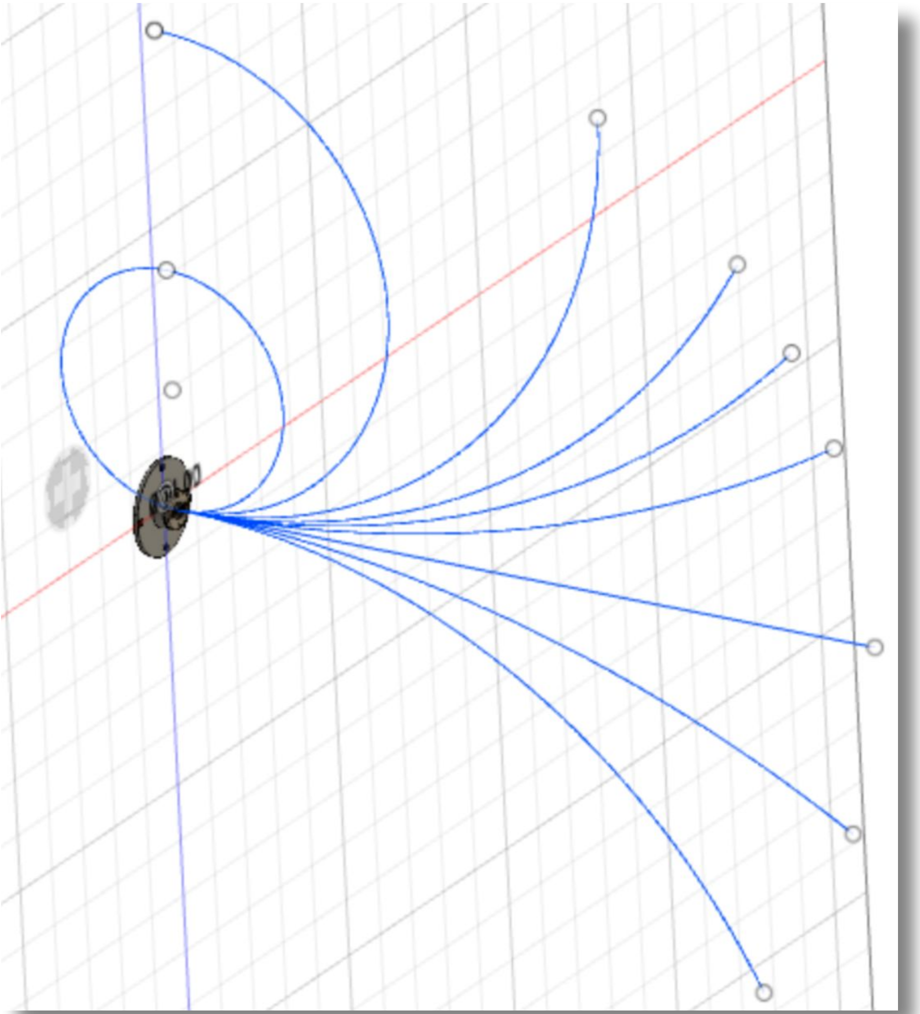


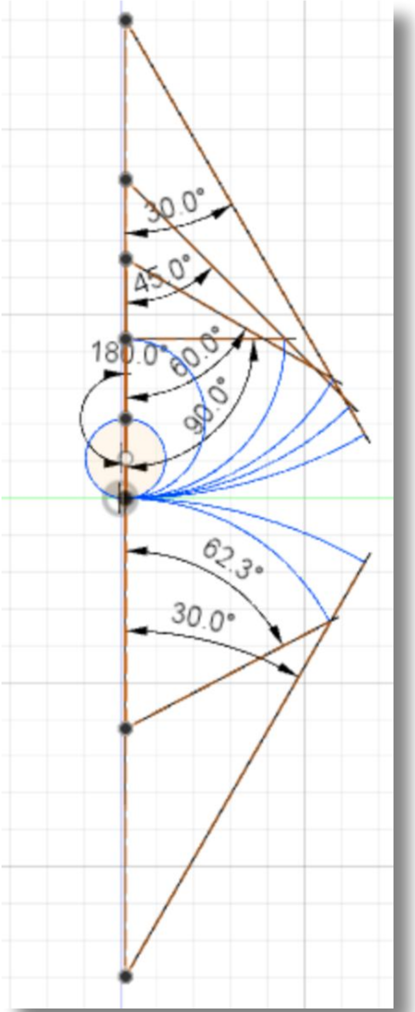


Significant Noises Observed when encountering gravity

Measurement 4: Motion

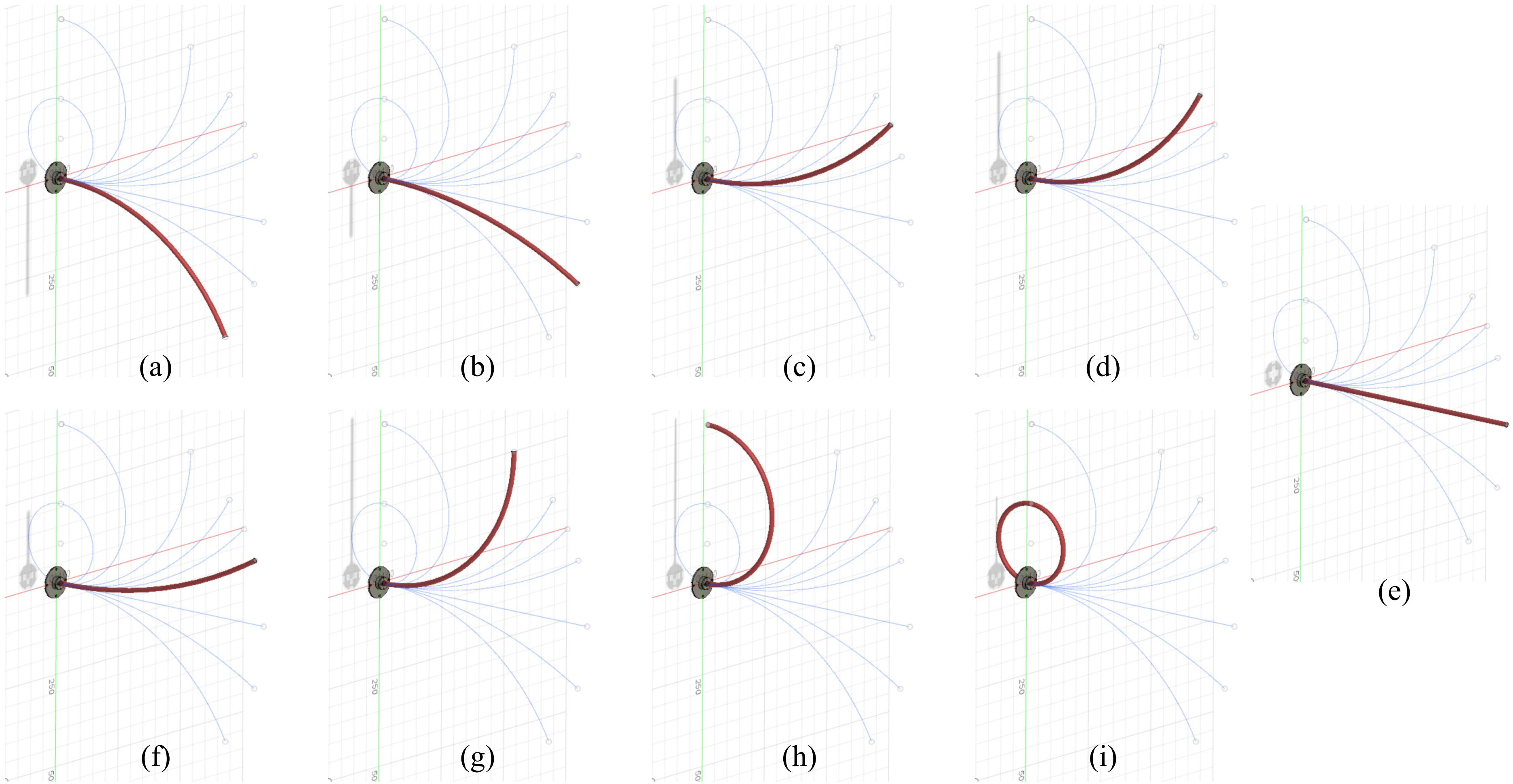






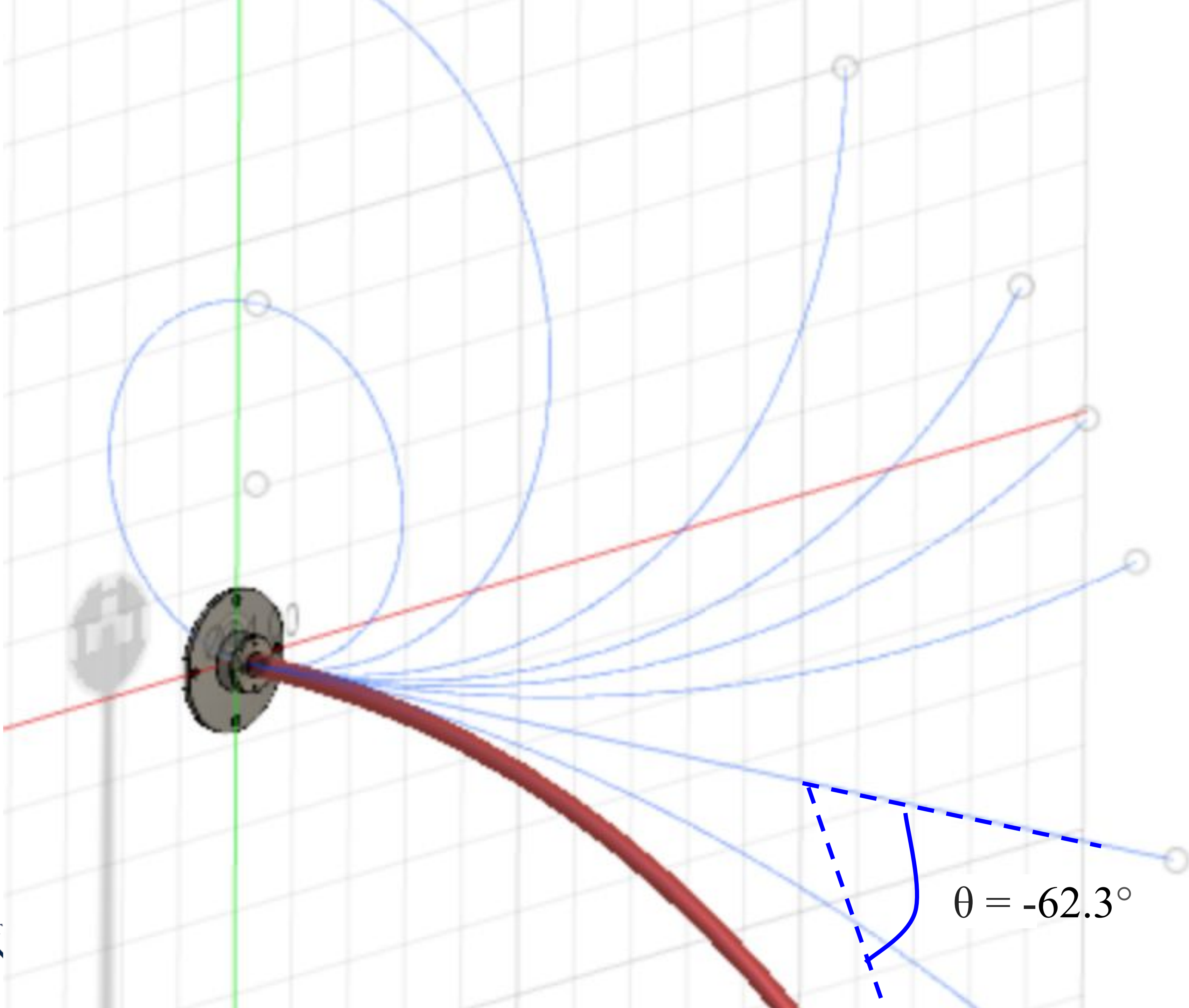
Simulation based on Real Data Gravity Considered

Measurement 5: Force to Different Angle

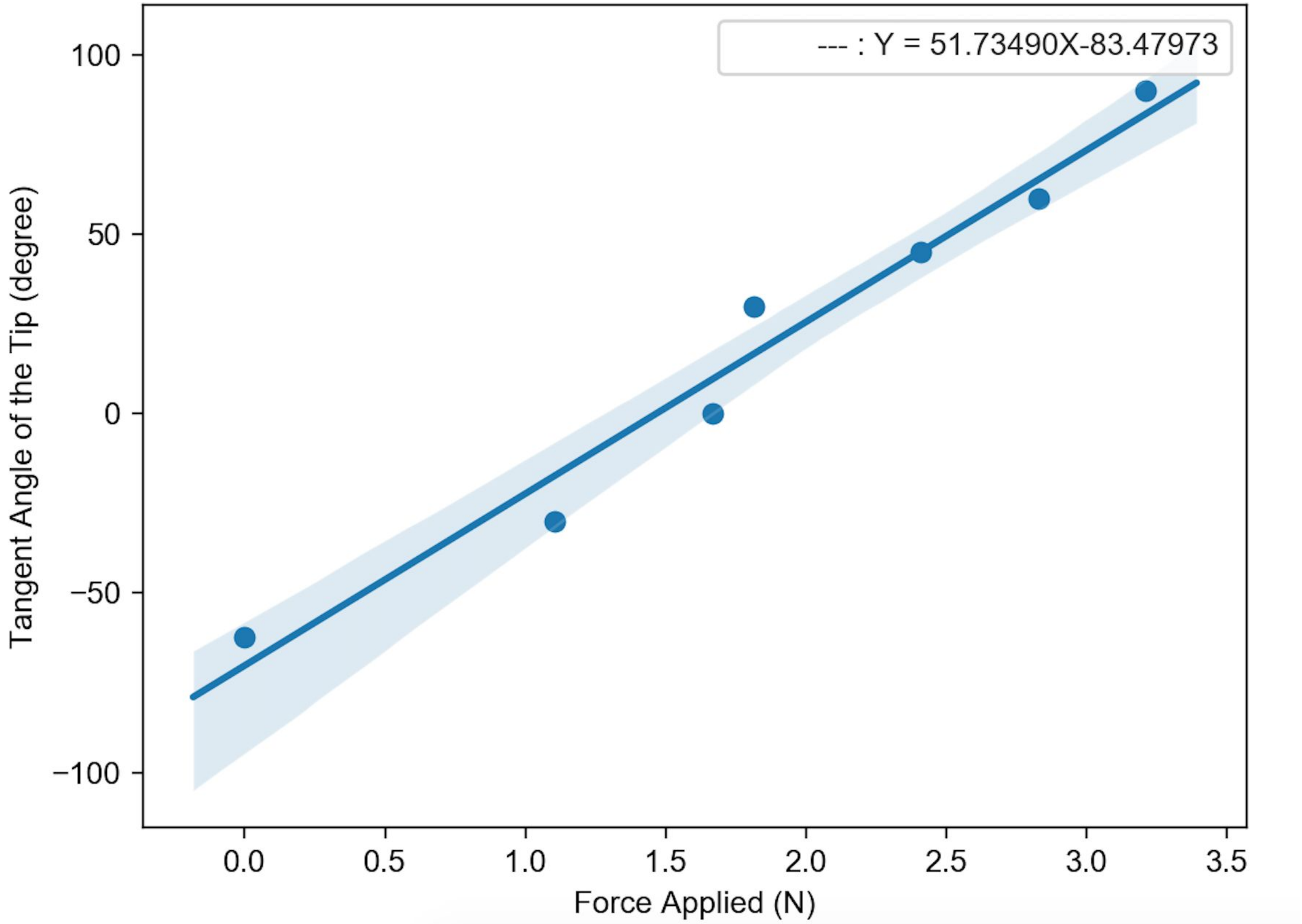


Angle Measured in degree:

-62.3
-30
0
30
45
60
90
180
360


θ = -62.3°

Measurement 5: Force to Different Angle



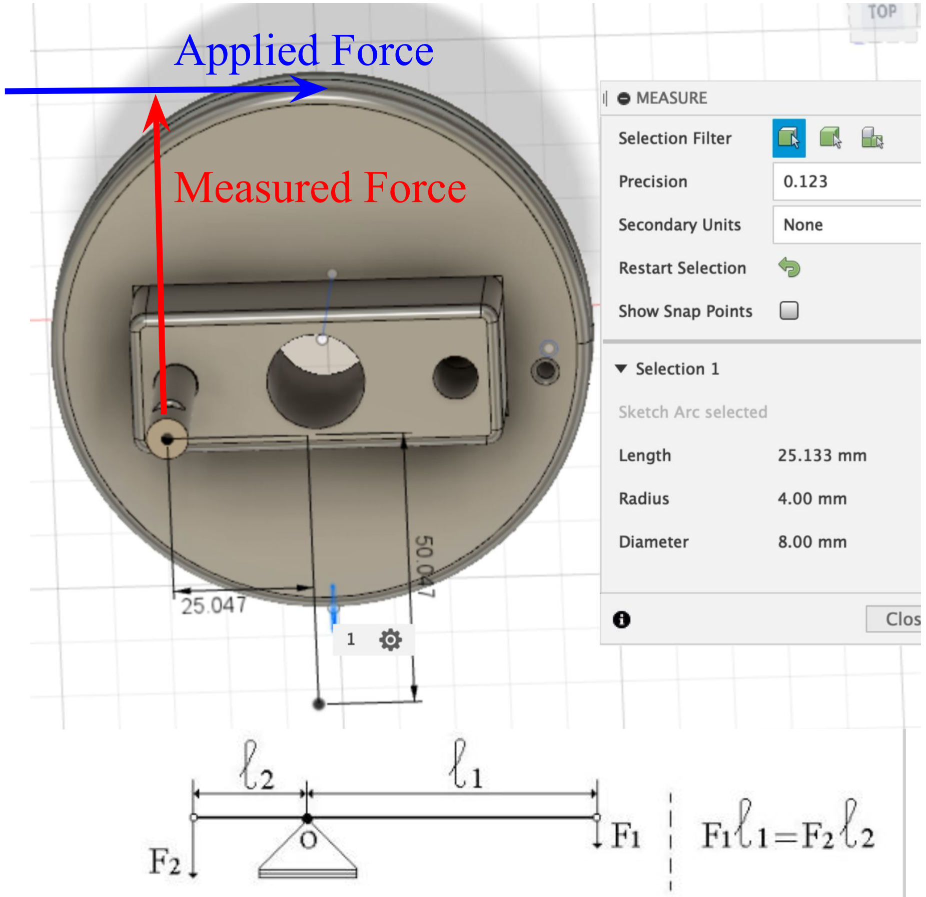
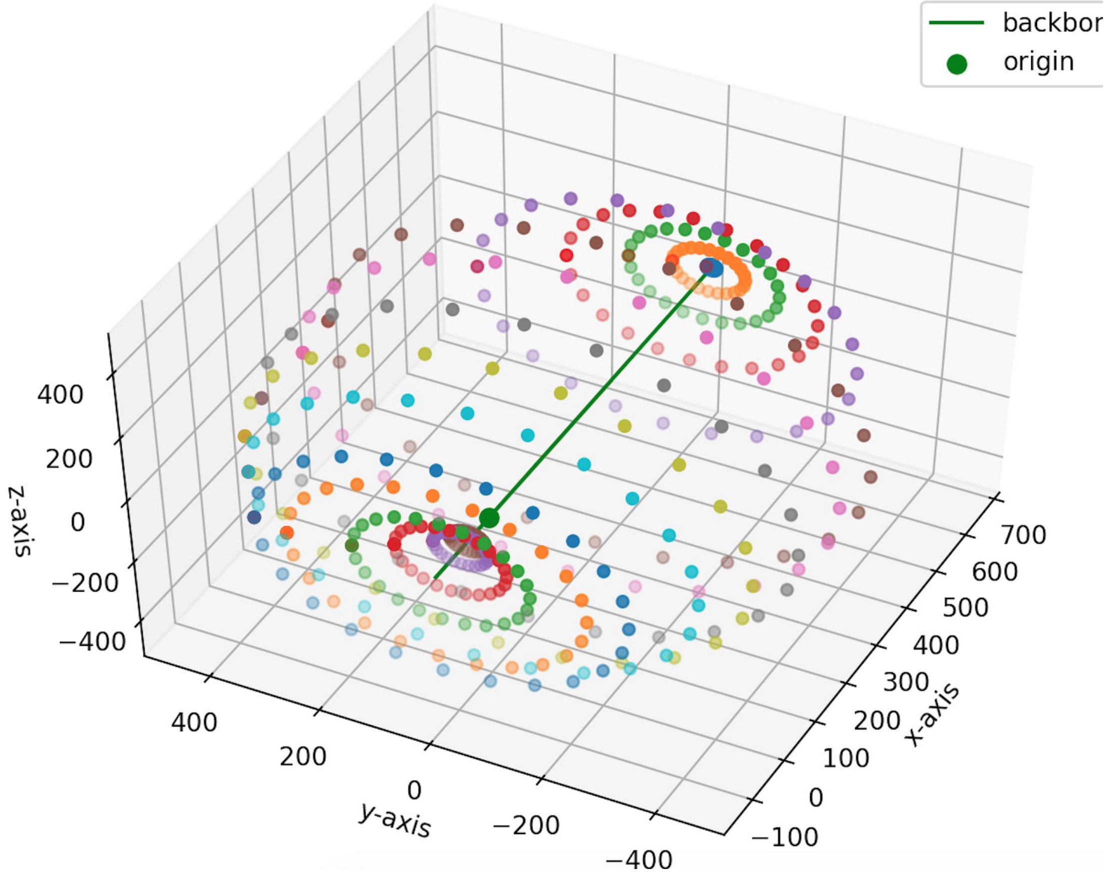
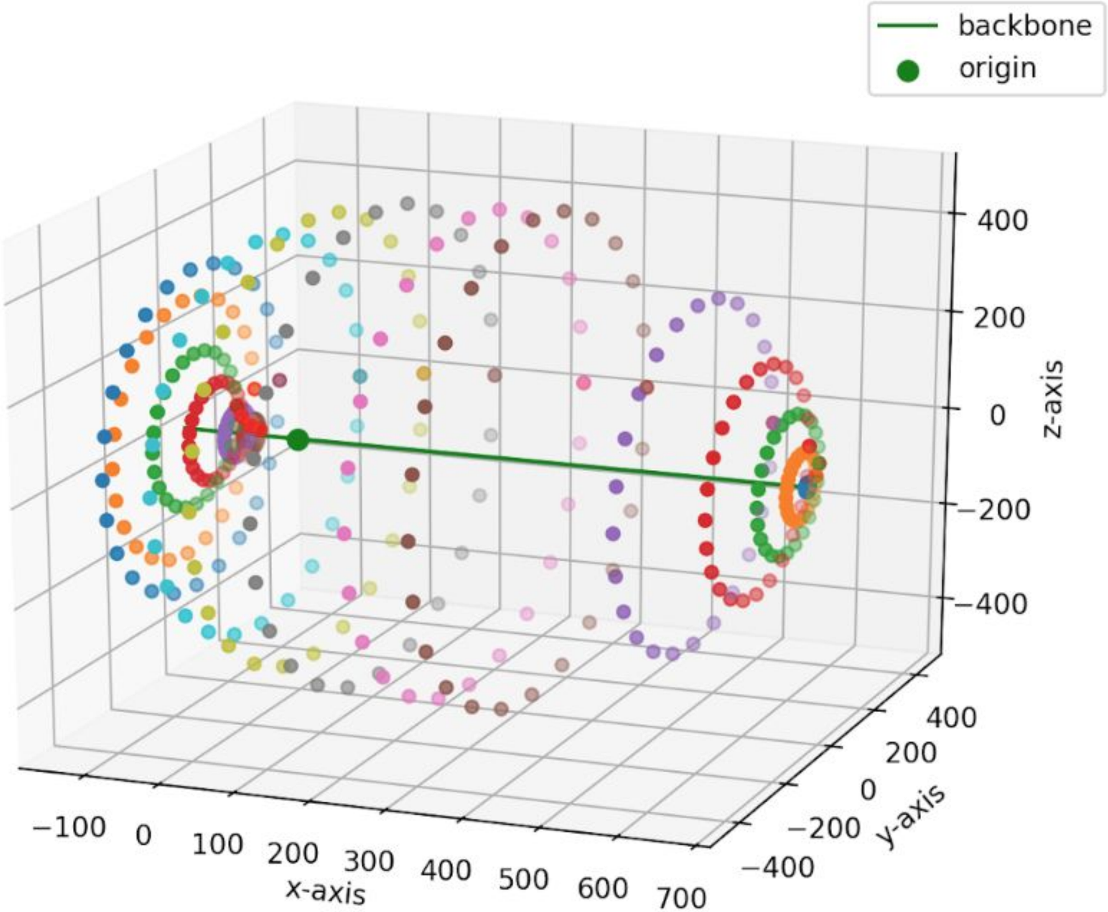


Fig.1

Applied Force = 0.5439 x Measured Force

Measurement 6: 3D Workspace





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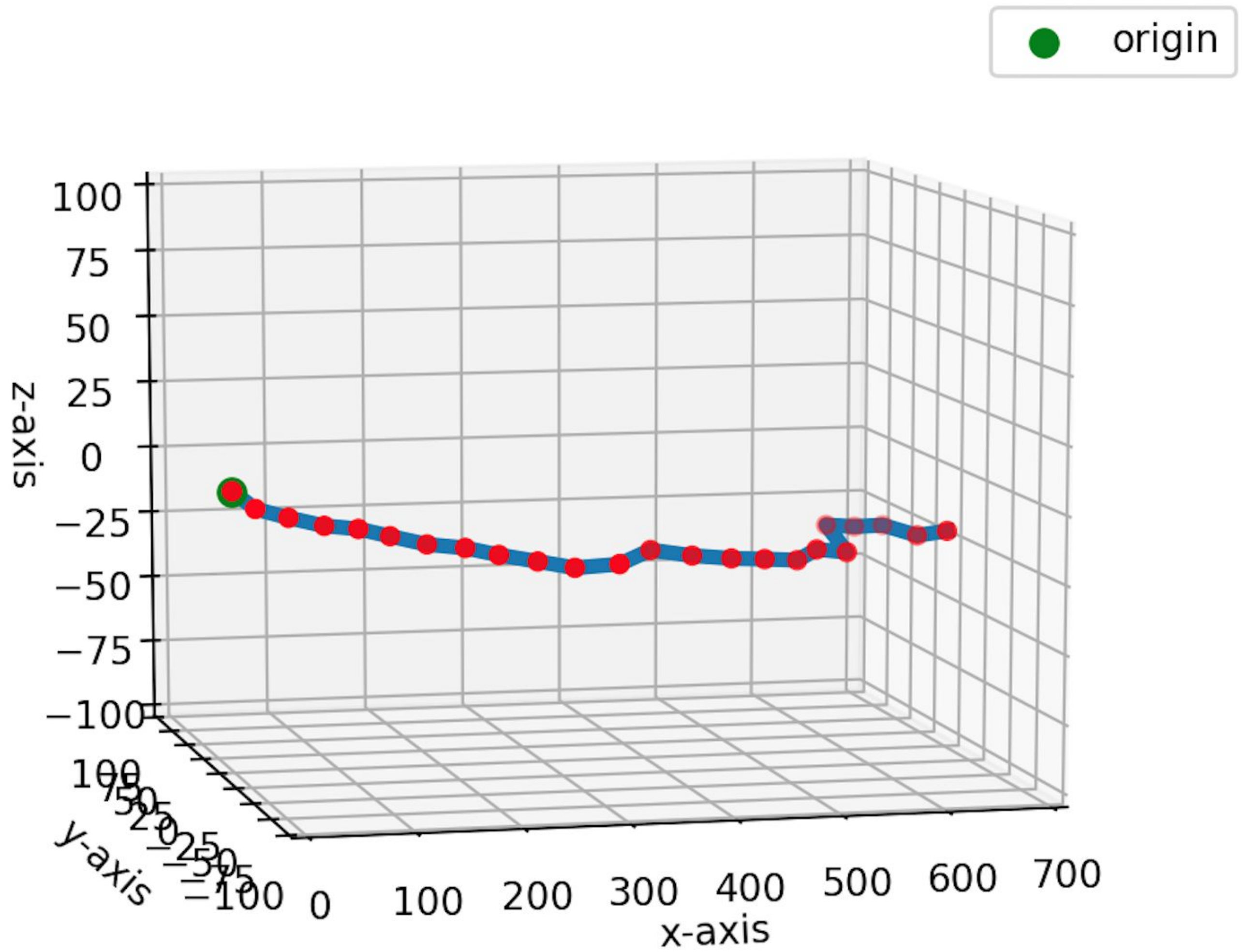
Measurement 7: Position for Naturally Bend down

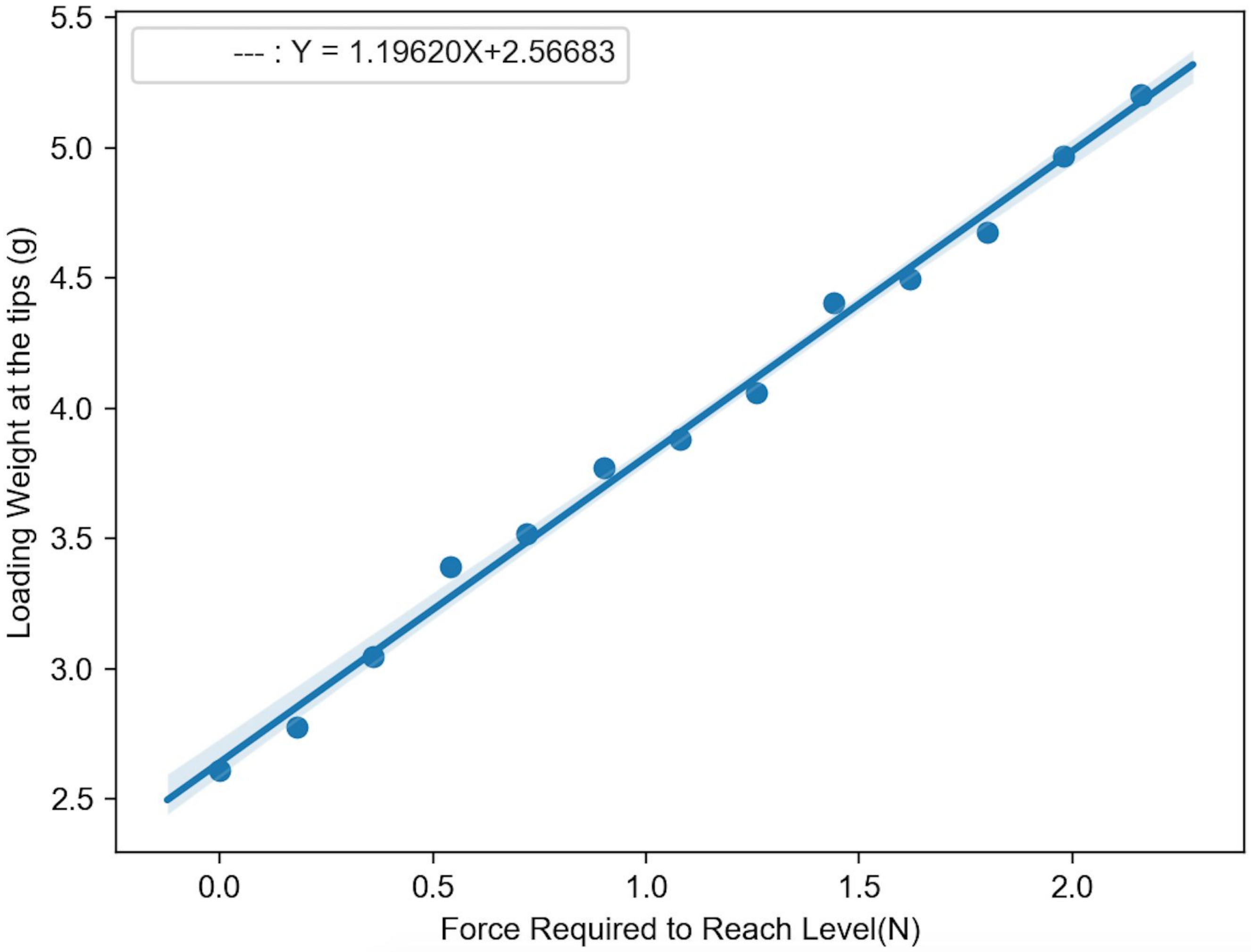


Measurement 8: Force Required to level under loading at the tip

0.18g/each

Measurement 8: Force Required to level under loading at the tip

* The Weight recorded does not include the loading tip, which is 0.6g



Summary of the Current Issues:

- Twisting of the robot
- Hardly self balanced after (3g+0.6g)’s load
- Tip is really hard to control (even without weight)
- Threshold exist for actuation

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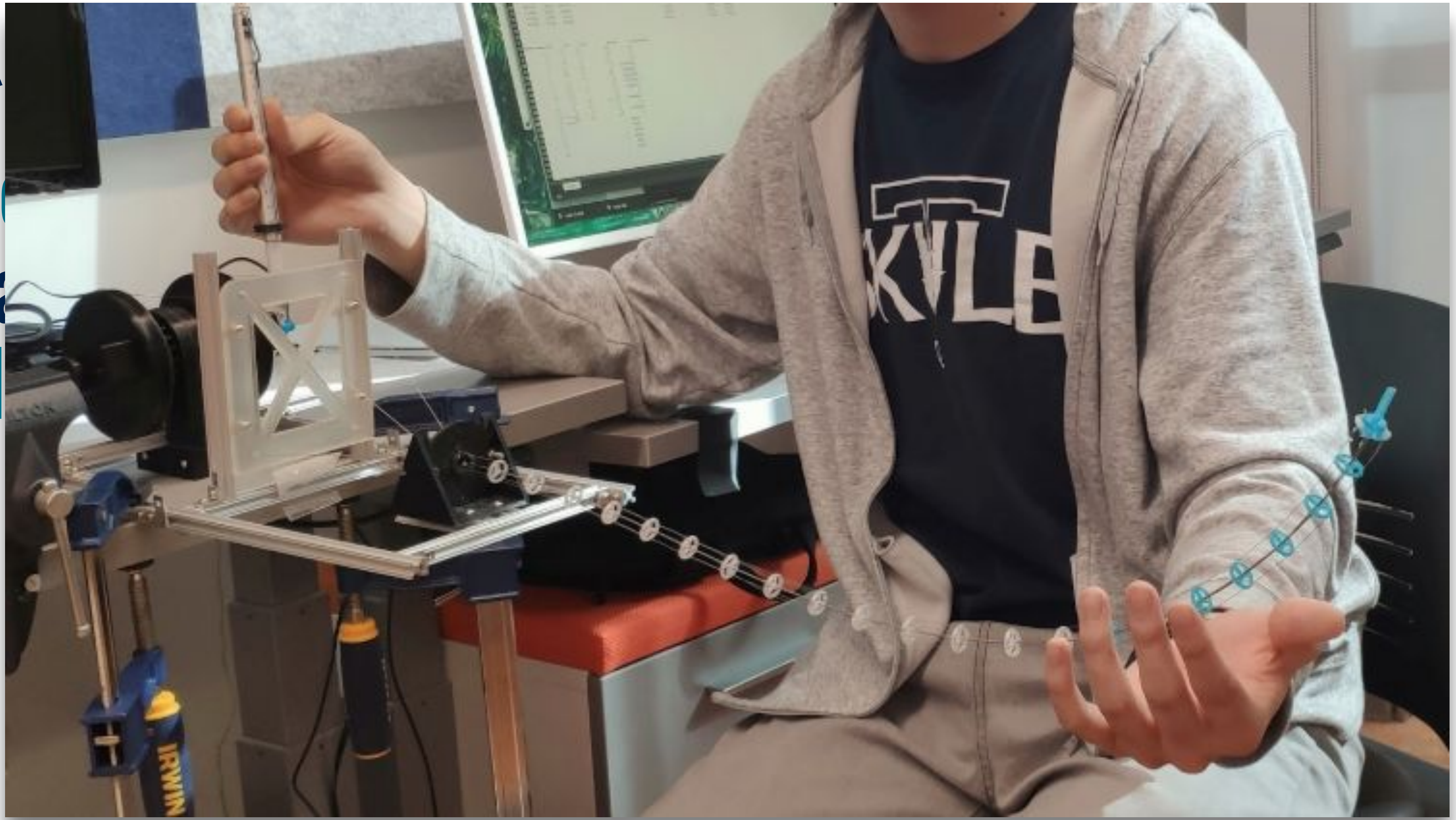

Summary of the Current Issues:

- Need stronger connections
- Twisting of the robot
- Hardly self balanced after (3g+0.6g)'s load
- Tip is really hard to control (even without weight)
- Threshold exist for actuation

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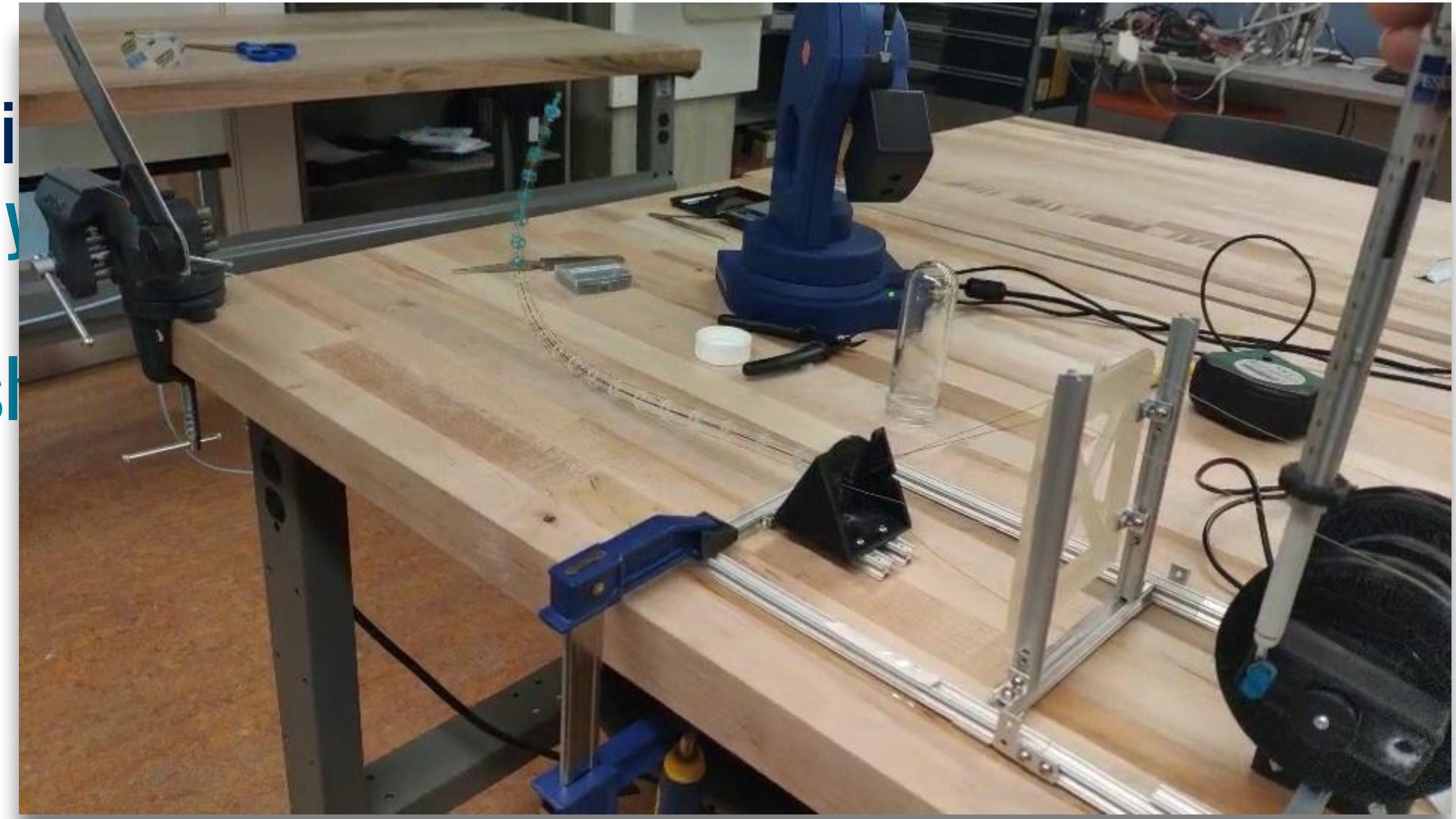
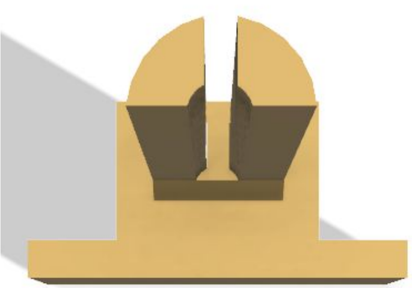


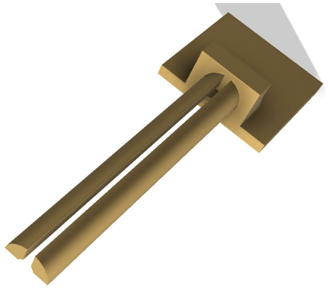
Summary of the Current Issues:

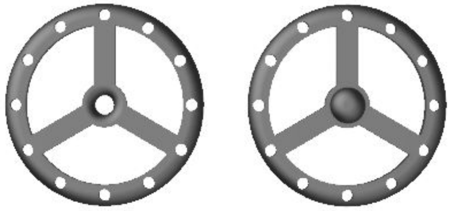
- Twisting of the robot
- Hardly self balanced after (3g+0.6g)'s load
- Tip is really unstable
- Threshold exist for actuation

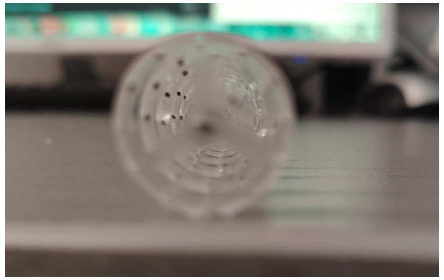
Improvement for Future Project:

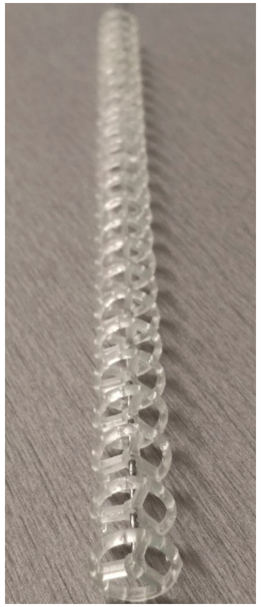
- Use Thicker Disks !!
- Use alignment Tool while building
- The density of the locking mechanism teeth need to be higher
- Time saving knotting skill --- Zeppelin Bend Knotting
- Better Measurement

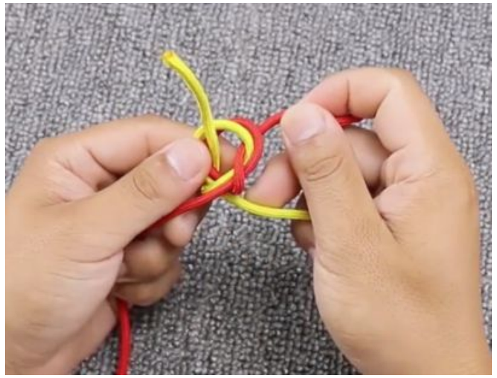












Zeppelin Bend Knotting

Conclusion

- Still need some mechanisms to stabilize a long and thin continuum robot
  - Need to prevent high torque and withstand the self load and payloads
  - Connections between robot's components are not strong enough

- Does multi-layer Jamming actually work to achieve above requirement?

- Tripod mechanisms might be a better solution.

Bibliography

Hansen, S. (2019). *Continuum robot offers brand new possibilities*. [online] MTU AEROREPORT. Available at: https://aeroreport.de/en/innovation/continuum-robot-offers-brand-new-possibilities [Accessed 29 Aug. 2019].

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