Using Pneumatics to Improve Toy Lightsabers

John Chen, Katya Morozov, Sean Shitamoto, Elvy Yao (6/9/23)

APICAL ROBOTICS

Work Multipliers
UCSB ME153 – Spring 2023

UC SANTA BARBARA mechanical engineering

Figure 3. Vine-saber with a red glow

Problem Statement

Current toy lightsabers on the market are:

- **Slow**
- **No automatic retraction**
- **Dangerous (hard plastic)**

Our Solution

We used **pneumatic soft robot technology** to create a Vine Robot Lightsaber that offers:

- **Rapid extension** using a clutch mechanism
- **Motorized retraction**
- A **soft, inflated** Dyneema blade (safe)

Internals Showcase

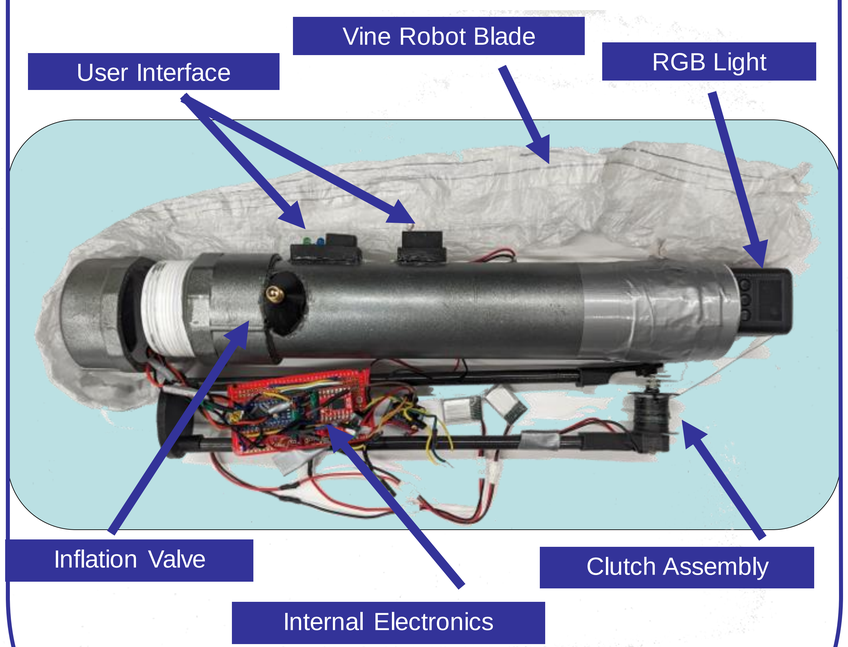


Figure 2. Internal showcase of the various subsystems in our lightsaber

Operation

•Our lightsaber is **initially pressurized** using a Schrader Bike Valve in its fully extended state to x Psi.

•It is then able to be **spooled** using the limit switch button on the hilt.

•Once the lightsaber is in its fully retracted state, users can rapidly extend the blade by depressing the button at the top of the hilt to **unclutch** the spool.

•The pressure in the hilt will cause the lightsaber blade to **extend**.

•An RGB Lume Cube allows the lightsaber to **glow** to a user-specified color.

Clutch Design

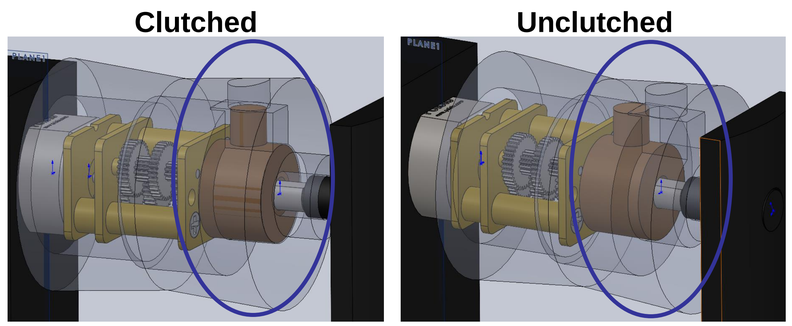


Figure 4. Clutch Assembly

- A mechanical button on our hilt physically slides our spool off the motor shaft allowing it to free spin
- A spring is located opposite the button to passively return the spool back into position

Measured Performance

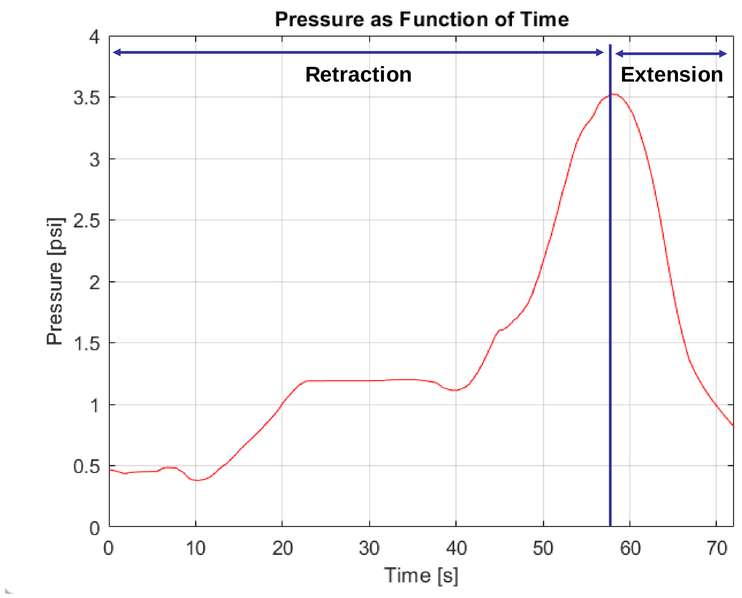


Figure 5. Pressure inside the vine-saber as it retracts and extends as a function of time taken using an Adafruit MS8607 pressure sensor.

Conclusion

We successfully created a prototype lightsaber using pneumatic soft robot technology. **We achieved our base criteria of fast extension, smooth motorized retraction, and illuminating the blade.**

We faced major challenges in buckling, choosing motor specifications, and switching design decisions deep in our design process.

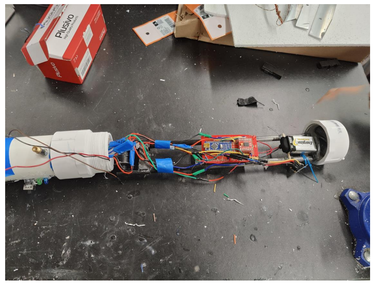
Future works that we were not able to address would be faster spooling using a spring and improving the leaks in the lightsaber handle.

Acknowledgments:

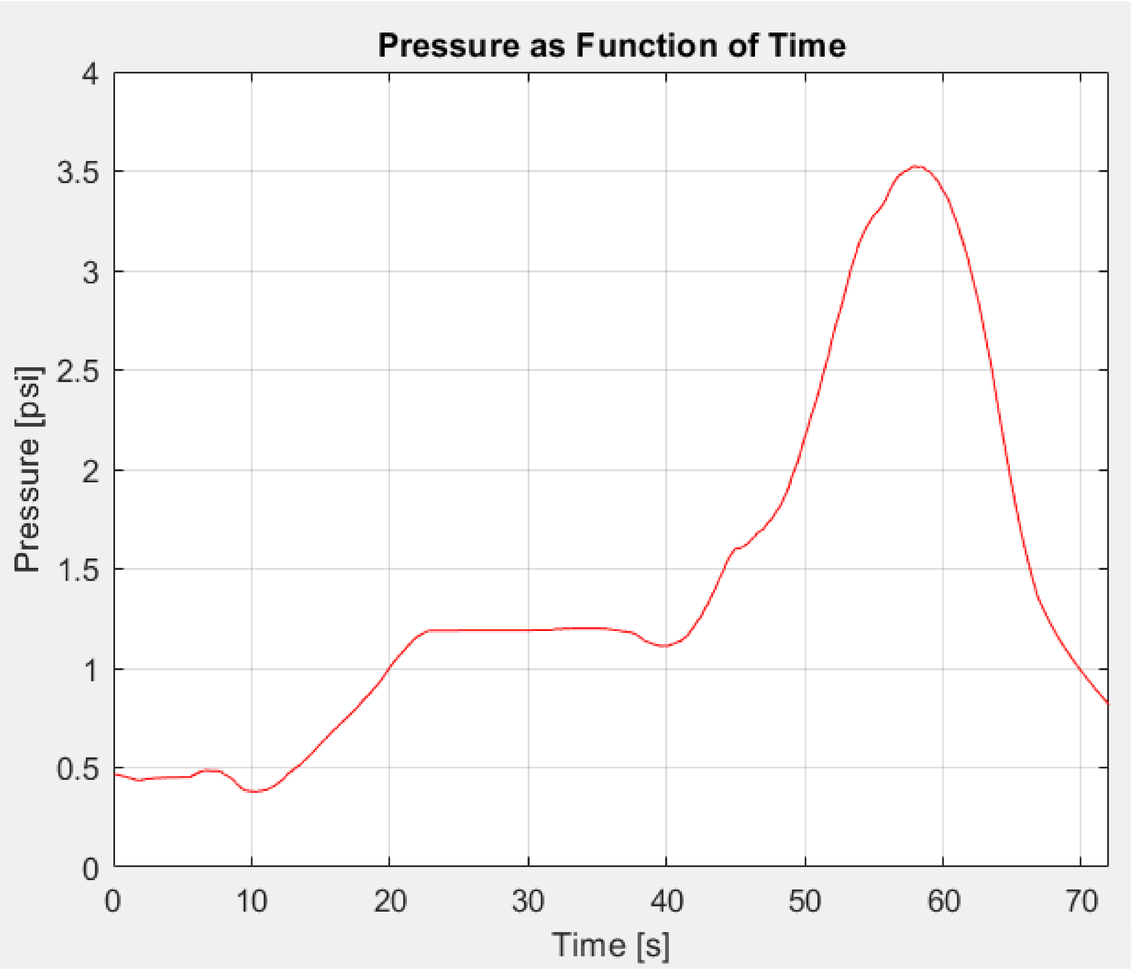
Professor Hawkes, Dr. Marks, Matt Devlin, Charles Xiao, Anders Seawright

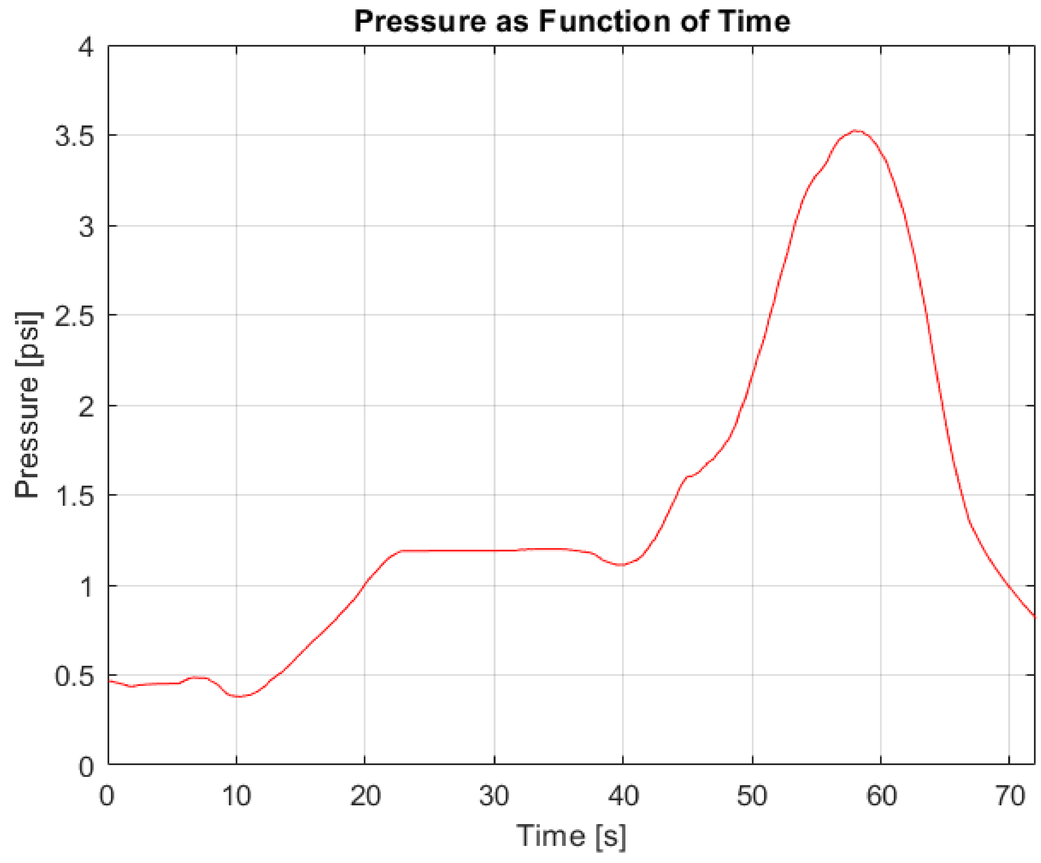
References

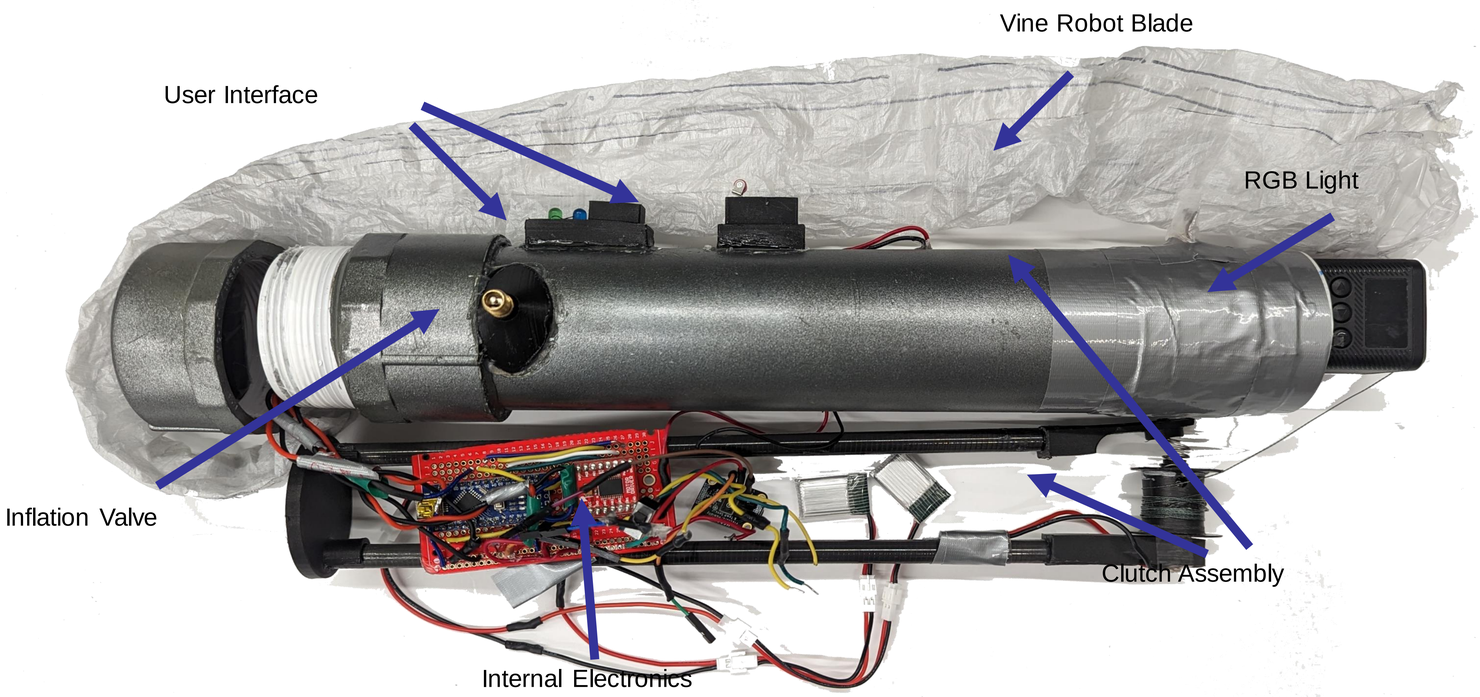
M.M. Coad, R. P. Thomasson, L. H. Blumenschein, N. S. Usevitch, E. W. Hawkes and A. M. Okamura, "Retraction of Soft Growing Robots Without Buckling," in *IEEE Robotics and Automation Letters*, vol. 5, no. 2, pp. 2115-2122, April 2020, doi: 10.1109/LRA.2020.2970629.

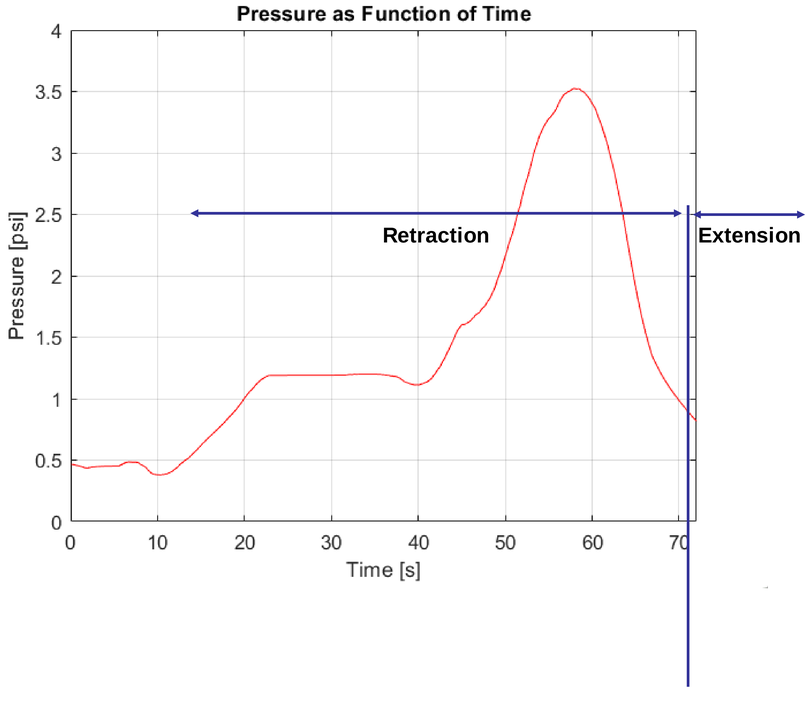


APICAL ROBOTICS


Pressure as Function of Time
Pressure [psi]
Time [s]
0
0.5
1
1.5
2
2.5
3
3.5
4
0
10
20
30
40
50
60
70


Pressure as Function of Time
Pressure [psi]
Time [s]
0
0.5
1
1.5
2
2.5
3
3.5
4
0
10
20
30
40
50
60
70


Vine Robot Blade
User Interface
RGB Light
Inflation Valve
Clutch Assembly
Internal Electronics


Pressure as Function of Time
Pressure [psi]
Time [s]
Retraction
Extension
0
0.5
1
1.5
2
2.5
3
3.5
4
0
10
20
30
40
50
60
70

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Problem Statement

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Our Solution

We used **pneumatic soft robot technology** to create a Vine Robot Lightsaber that offers:

- **Rapid extension** using a clutch mechanism
- **Motorized retraction**
- A **soft, inflated** Dyneema blade (safe)

Principal Concept: Vine Robots

- Vine robots consist of a **soft tube** that grows with increasing **pressure.** Vine robots extend through **eversion**, where tail material grows from the middle of the tip. We used these properties to create a **soft lightsaber blade**

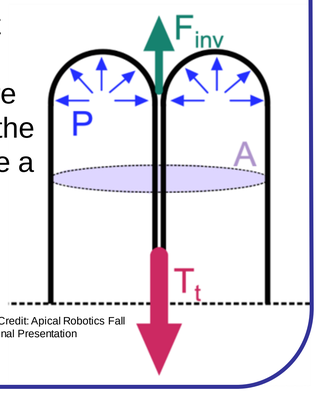

Image Credit: Apical Robotics Fall 2022 Final Presentation

Figure 1. Retracted and Extended split (potentially explaining vine robots)

Internal Showcase

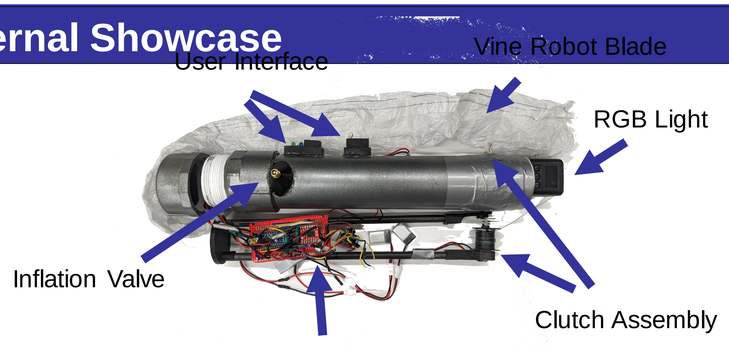

Figure 2. Internal showcase

Figure 3. Replace with picture of current Saber

Operation

•Our lightsaber is **initially pressurized** using a Schrader Bike Valve in its fully extended state to x Psi.

•It is then able to be **spooled** using the limit switch button on the hilt.

•Once the lightsaber is in its fully retracted state, users can rapidly extend the blade by depressing the button at the top of the hilt to **unclutch** the spool.

•The pressure in the hilt will cause the lightsaber blade to **extend**.

•An RGB Lumecube allows the lightsaber to **glow** to a user-specified color.

Clutch Design

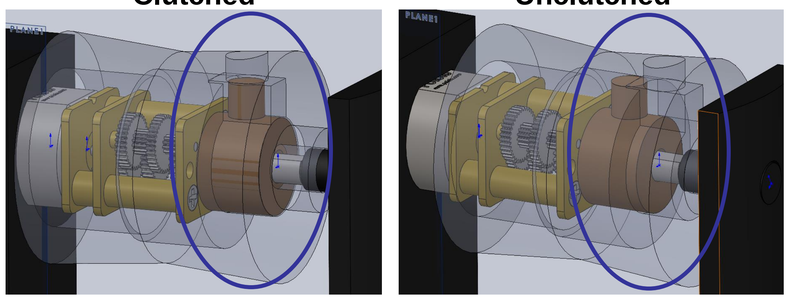

Figure 4. Clutch Assembly

- A mechanical button on our hilt physically slides our spool off the motor shaft allowing it to free spin
- A spring is located opposite the button to passively return the spool back into position

Measured Performance

Pressure range, extension/retraction speed, # uses before too much air leaks and it stops working properly, pressure as a function of use-cycles, …?

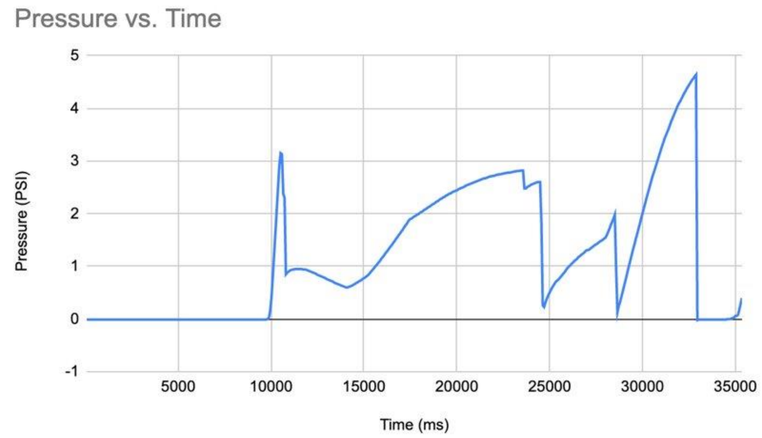

Figure 5. Replace with new Pressure Data

Conclusion

We successfully created a prototype lightsaber using pneumatic soft robot technology. **We achieved our base criteria of fast extension, smooth motorized retraction, and illuminating the blade.**
We faced major challenges in buckling, choosing motor specifications, and switching design decisions deep in our design process.
Future works that we were not able to address would be faster spooling using a spring and improving the leaks in the lightsaber handle.

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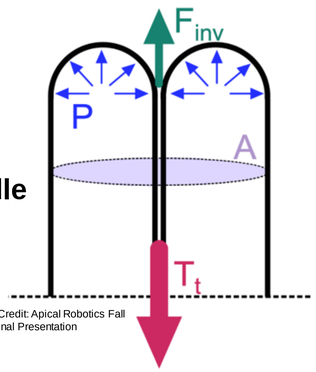
Our Solution

We used pneumatic soft robot technology to create a Vine Robot Lightsaber.

- **Rapid extension using a clutch mechanism**
- **Offers motorized retraction**
- **Inflates a soft Dyneema blade (safe)**

Principal Concept: Vine Robots

- **Soft cloth tube that extends with increasing pressure**
- **Extension is characterized by eversion:**
  - **Material grows through the middle from the tip**



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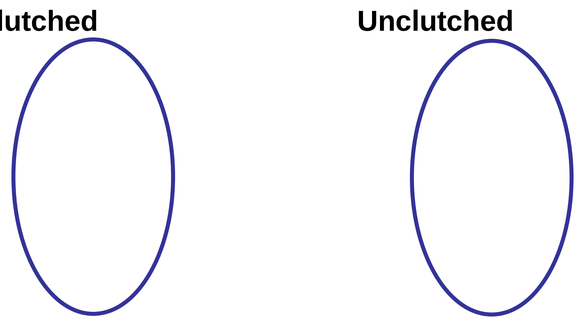

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Measured Performance

Pressure range, extension/retraction speed, # uses before too much air leaks and it stops working properly, pressure as a function of use-cycles, …?

Figure 5. Replace with new Pressure Data

Conclusion

- **Successfully made a prototype lightsaber using novel, portable,and pneumatic, soft robot technology.**
- **We achieved our base criteria:**
  - **Fast extension**
  - **Smooth motorized retraction**
  - **Glowing**
- **Some challenges we faced:**
  - **Buckling**
  - **Choosing correct motor specs**
  - **Moving from pressure controlled design to pre-pressurized**
- **Future Works:**
  - **Fast spooling**
  - **More airtight handle and body**

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