Robotic Endoscope Platform Technology V2.0

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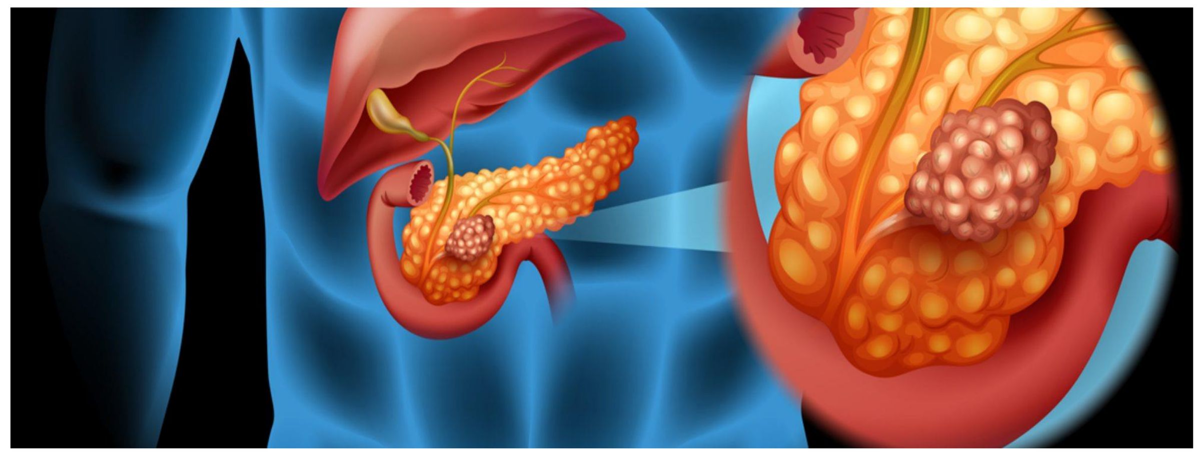
THE PROBLEM

***Pancreatic cancer is the #1 leading cause of death out of cancers.*[1]**

The five-year relative survival rate is 7% [2]; **less than one in ten people** diagnosed with pancreatic cancer will survive after five years. One main factor that contributes to this is the anatomical location of the pancreas. By traditional endoscope techniques, this region is not easily accessible, resulting in extremely late diagnosis.

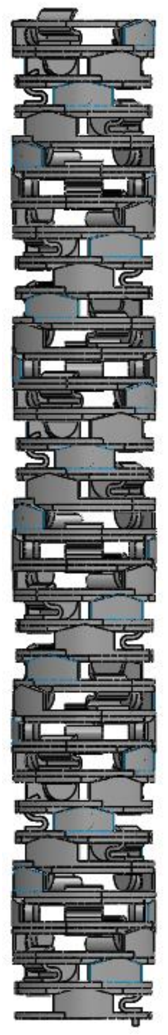


Our Goal: To develop an affordable endoscope that enables surgical access to obscure, hard-to-reach areas from anatomical obstructions by allowing multiple degrees of movement, while still being stiff during surgical procedures.

Our Scope: Improving the mechanical and electrical design of the endoscope by:

- Optimizing the size, shape, and positioning of the nitinol
- Optimizing the power delivery and control system, and
- Developing analytical tools to aid future design activities.

OUR SOLUTION



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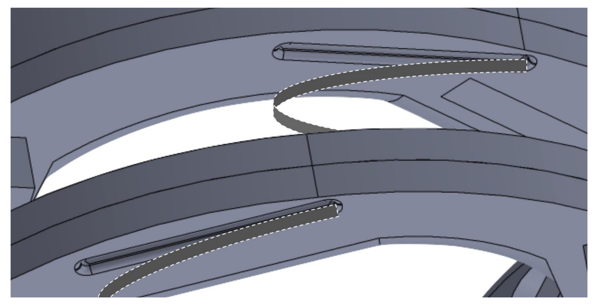

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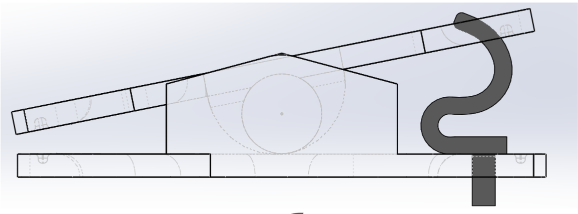

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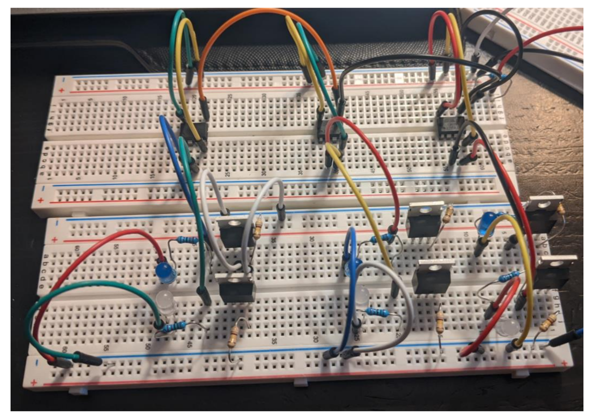

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Design Requirements:

- ❖ Cavity in the middle to support passage of camera and surgical tools
- ❖ Individual control of the actuators while keeping wires to a minimum
- ❖ Must provide enough force to overcome the locking mechanism

Key components:

Our design possesses the following features:

A. 3D Printed modular Chassis
B. Moon-shaped Nitinol Wire
C. S-shaped Leaflet
D. Electrical system to control actuation (pre-soldering)

Actuator System

- Prototyped from PA12 nylon with 15% carbon fibre
- Modular design; helically stacked (offset 60 degrees)
- 30 degrees actuation across two static positions
- Spring-lock leaflet which ensures locking of position

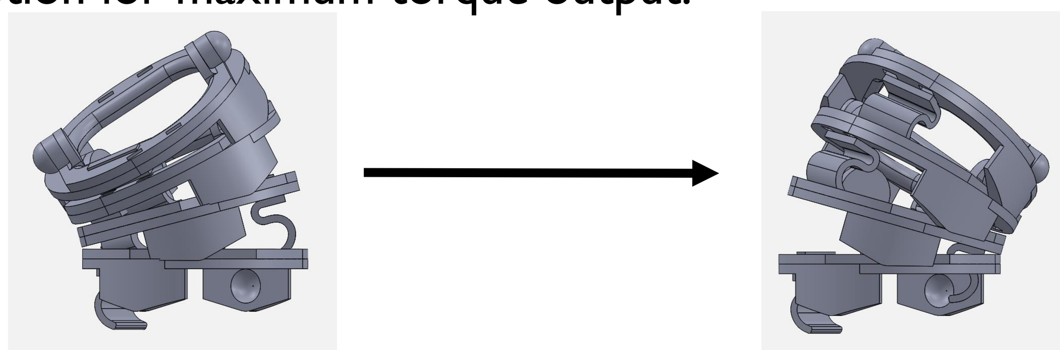
Electrical System

- Designed to handle a variety of different amperages depending on the size of the Nitinol with a variation of the transistors.

ACTUATOR SYSTEM

Nitinol Wire Use

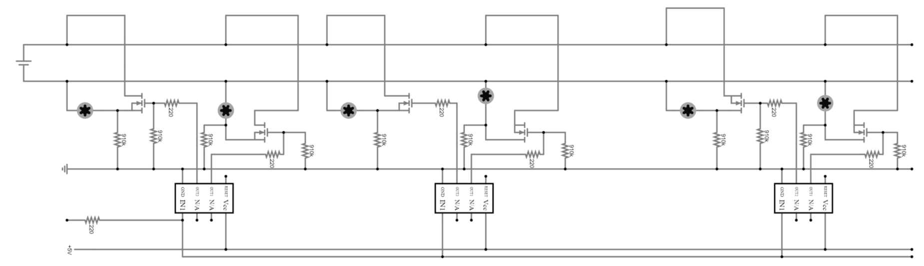
When nitinol wire is heated using electricity, it straightens from the flattened moon shape, providing force to mechanically push and actuate the chassis. Tabs secure the nitinol wire onto the chassis, perpendicular to the path of motion for maximum torque output.



Configuration 1 – Not heated *Configuration 2 – All heated*

ELECTRICAL SYSTEM

- Fully modular, easy to use, extremely compact and lightweight
- Since the number of links needed in for the endoscope is variable the circuit was designed to be modular, with its length changeable by a connection of five wires
- Works by having the Arduino communicate to microcontrollers through pulses.



TECHNOLOGIES

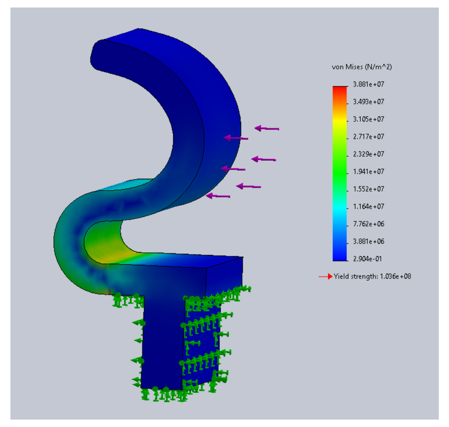
1) Traditional Endoscope: are either too flexible to be maneuvered or too stiff to have a wide range of motion.

2) DaVinci Surgical robot: this device is minimally invasive. However, it is expensive and inaccessible to the public.

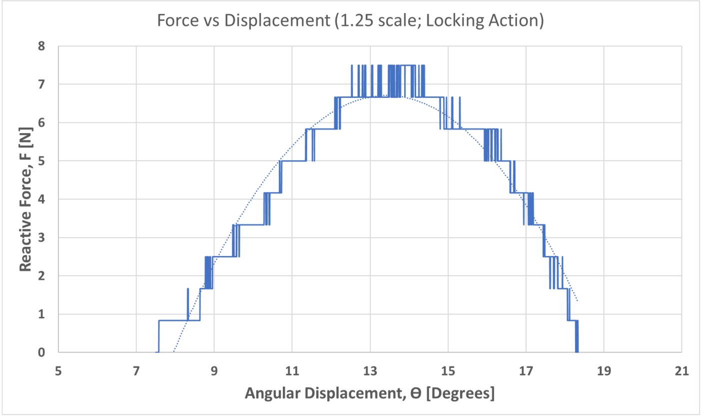
3) Robotic Endoscope V1.0: a previous capstone project; demonstrated feasibility of the concept and discovered an optimal stacking orientation. Inefficient torsional spring mechanism. DC current supplied was not scalable and there was inconsistent performance with the locking system

TESTING AND RESULTS

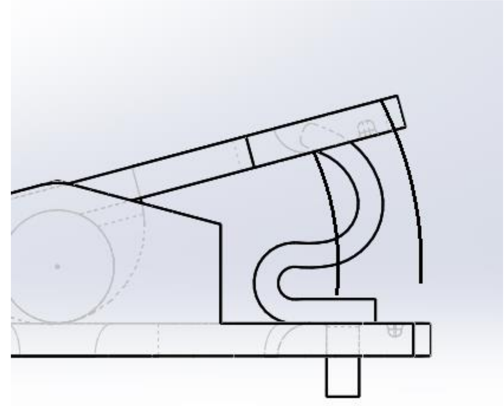
The mechanical operating parameters of the device is fundamentally dependent on the S-shaped leaflet. Testing was performed to validate the actuator design, along with analytical model. The following tests were performed:



Static Stress Analysis



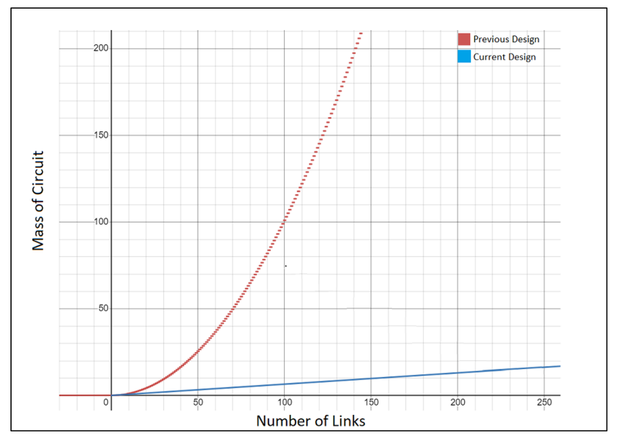
Actuation Force Testing



Motion analysis

Results:

- The new electrical system design exponentially decreases the weight of wiring with increasing links, allowing for scalability.
- The new actuator design requires less power, due to increased mechanical efficiency with optimized shape and positioning



CONCLUSION

- A proof-of-concept prototype was manufactured which successfully actuated the nitinol wire in each module.
- An independent electrical circuit system capable of producing more efficient actuation was developed.

Future Research and Development tasks:

- Exploration into setting the nitinol wire into a tailored shape for more efficient force application during nitinol wire expansion using a salt bath
- Leaflet material testing to withstand plastic deformation

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REFERENCES:

[1] *Hirshberg Foundation for Pancreatic Cancer Research*, https://pancreatic.org/pancreatic-cancer/pancreatic-cancer-facts/
[2] *John Hopkins Medicine*, https://www.hopkinsmedicine.org/health/conditions-and-diseases/pancreatic-cancer/pancreatic-cancer-prognosis
[3] https://pathology.jhu.edu/pancreas/basics/function