Handheld Robotics for Endoluminal Procedure Automation

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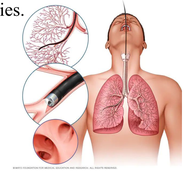
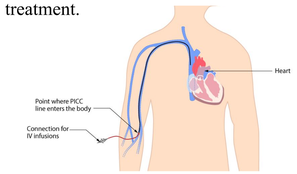
Background & Medtronic C.A.R.E.S.

Endoluminal Surgical Solutions

- Lung Biopsy: Endoluminal surgery is an invasive surgery allowing for corrective procedures or biopsies.

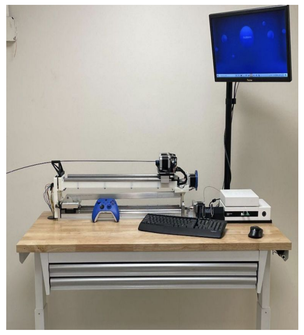


- Intravascular Therapy Delivery: Endoscopy through cardiovascular system to deliver targeted treatment.



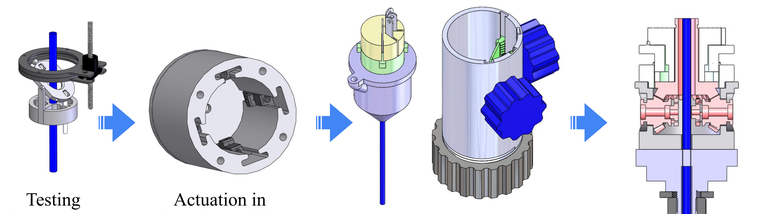
Previous Work - C.A.R.E.S

- 2022 Graduate Students worked with Medtronic on Catheter Automation for Robotic Endoscopic Surgery (C.A.R.E.S)
- They built a tabletop endoscopic device with AI integration to control navigation.
- The unit was roughly 36”x6”x6” in size, and weighed over 100lbs.



Common Catheter Interface

Common Catheter Interface (CCI) Prototype Development Stages

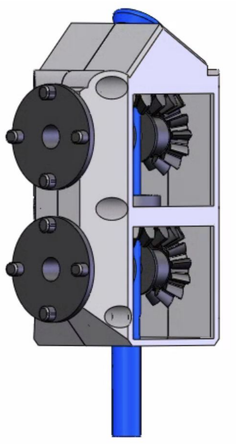


Testing Simultaneous Rotation and Articulation

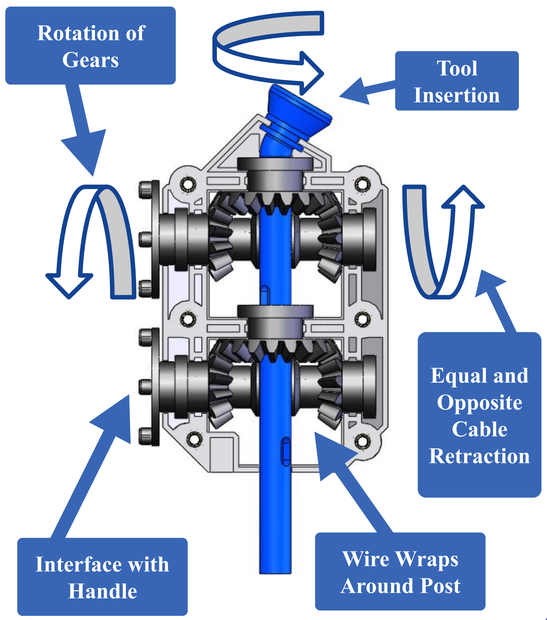
Actuation in Four Planes Via Sliders

Hooks and Custom Gears Allow CCI to Handle Interface

Clutch Mechanism Allows Rotation Separate from Actuation



Final CCI Design



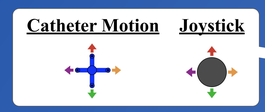
Mission

The objective of this project was to create a handheld endoluminal intervention device. This involves taking the previous graduate team’s design, a large and heavy tabletop device, and reducing the size and weight such that it could be comfortably held by a physician for an extended period of time. In addition, we needed to create a universal adapter for existing catheters which would allow a variety of catheter types and sizes to be controlled by the same electromechanical handle.

Objective

A clinician, with little technical training, needs to quickly and reliably navigate with real time physical and visual feedback to a specific location within the human body. By creating an easy to use, intuitive system, our device reduces the procedure time and increases accuracy of distal tip placement.

Electromechanical Handle with CCI



Electromechanical Handle

An ergonomic and ambidextrous handle with embedded electronics for precise control of the distal end of the catheter through actuation of the CCI.

Common Catheter Interface (CCI)

A disposable common attachment accommodates various sizes and styles of catheters for different purposes.

Electronics Housing

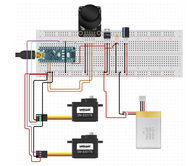
Electronics are all contained within a small housing enclosure that allows the device to be easily cleaned and reused

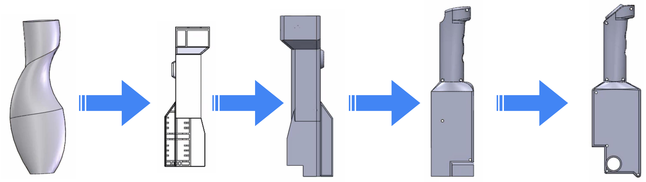
CCI Attachment

A spring loaded snap firmly connects the CCI to the handle, locking it securely in place

Electromechanical Handle & Electronics

- Catheter distal tip is controlled by joystick actuated servos with embedded rotary encoders
- Ergonomic handle allows comfortable use by right or left hands and small or large hand sizes
- Joystick positioning allows convenient tool insertion into catheter working channel
- Haptic sensors were also considered for feedback but were removed after discourage from users while testing.





Progress of Handle shape with each phase and user usability tests

Results and Future Work

User Testing

Mechanical Handle

Electromechanical Handle

Final Model Development

User testing was completed at the end of every phase; mechanical (1), electromechanical (2), and final model development (3). Feedback was documented to improve the design in future iterations.

Final Product Specifications

1.	Height	270mm
2.	Width	70mm+33mm(CCI)
3.	Weight	457g
5.	Angle Articulation	-75 to +75 degree
6.	Right Hand or Left Hand	Both

Future Operations

- Teleoperation: Connecting the device to a tabletop robot would allow for a clinician to remotely perform procedures with the touch of a button.
- Autonomous Procedures: By incorporating route planning processes to the teleoperation phase, endoscopic surgeries could be completed autonomously

Tabletop Robot

We would like to express our heartfelt gratitude to Mr. Jing Zhao, Dr. Rebecca Komarek and Mr. Levin Silker for their utmost support and guidance throughout the duration of the project.