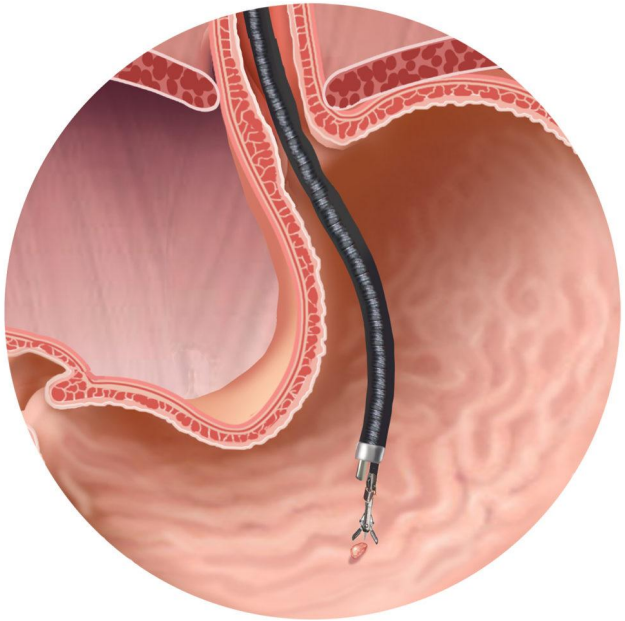
Reinventing the Modern Endoscopy: Safer Wireless Methods



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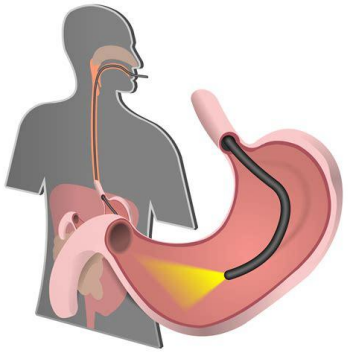
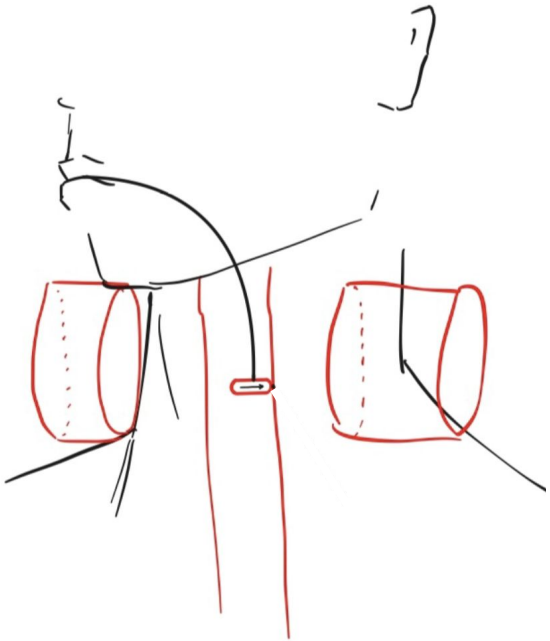
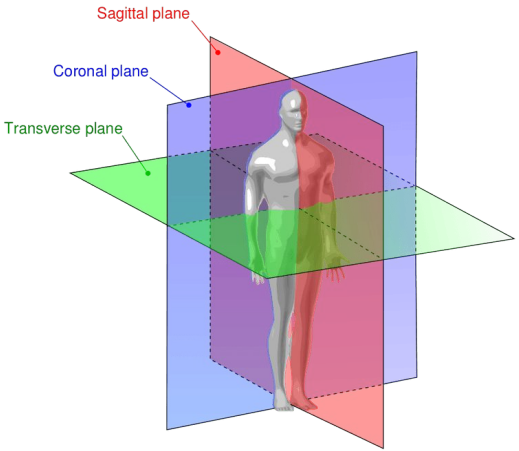
Problem Statement

- Modern endoscopy methods are highly invasive
  - Anaesthesia
  - Operating Room procedure
  - Risky for patients over 60
- Wireless methods are passive, no locomotion control
- Stereotaxis Niobe is bulky, MRI like, hard to move.



Our Solution





Main Questions

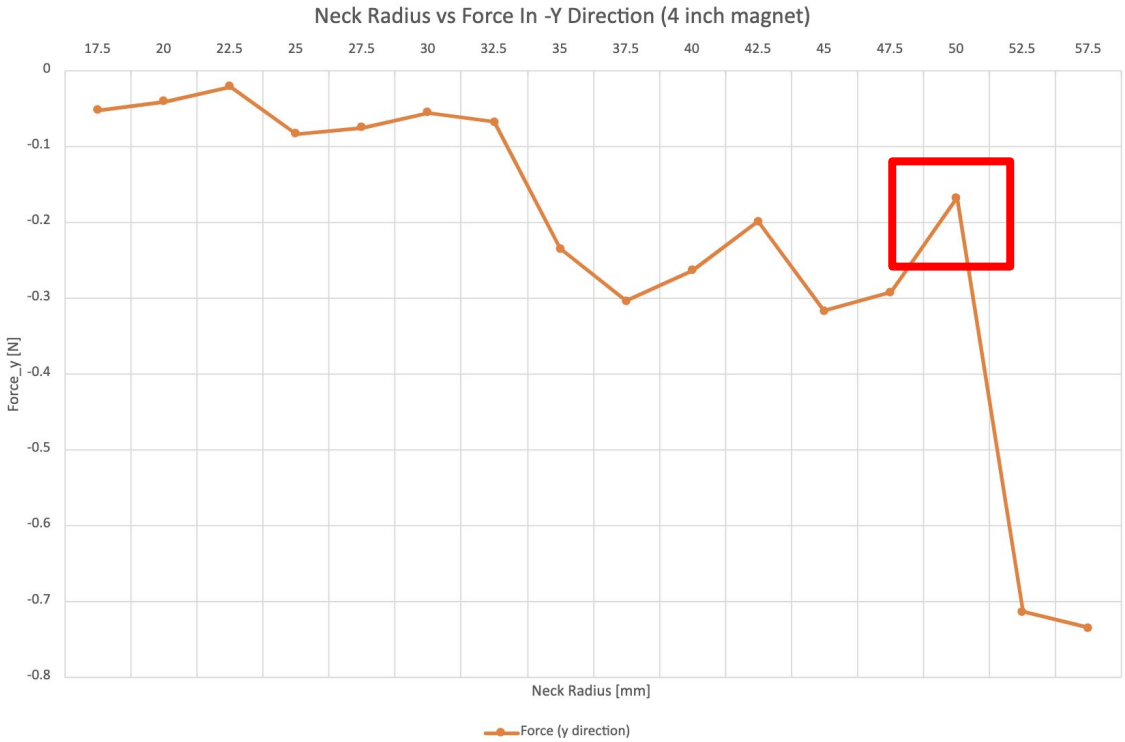
1. Can we safely locomote the capsule without tearing the esophagus wall?
2. How do magnetic fields affect the body?
3. Can we control the capsule's position reliably?
4. Can we disrupt current endoscopy methods by developing a safer, quicker procedure?

Methods

1. Electromagnetic modeling in JMAG
2. Choose an appropriate neck model size
3. Mold a model neck & esophagus in silicone, include force sensors
4. Choose hardware: motor driver, current sensor, microcontroller, force sensors
5. Design control loop inputs
    a. Position control
    b. Current control
    c. Force control
6. Tune control loop

Neck Size vs Force (Modeling in JMAG)

*All data collected for a 4 inch electromagnet.



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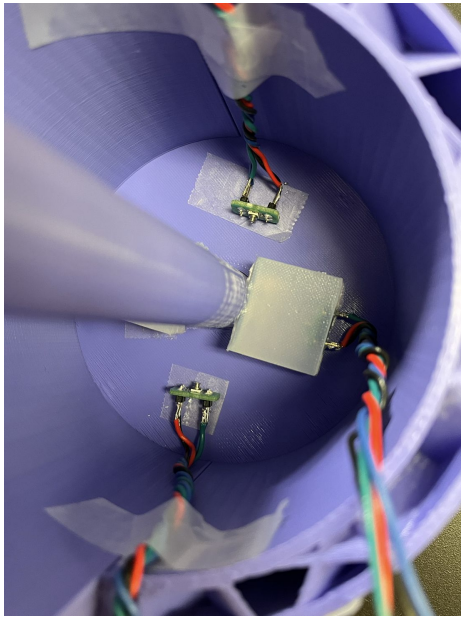
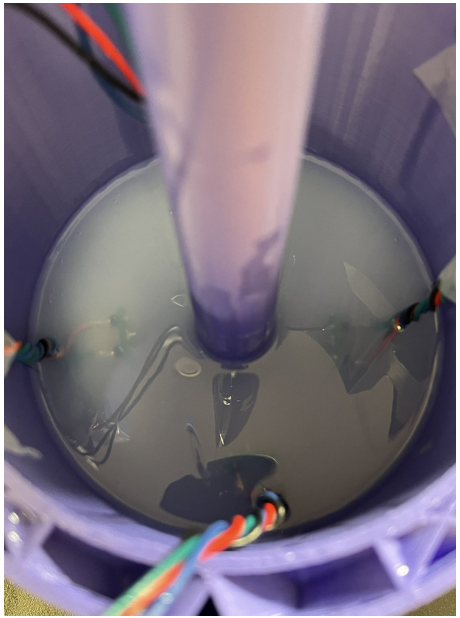
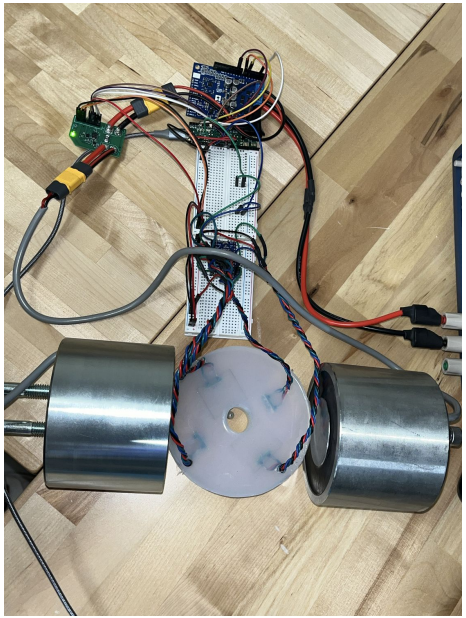
Experimental Setup







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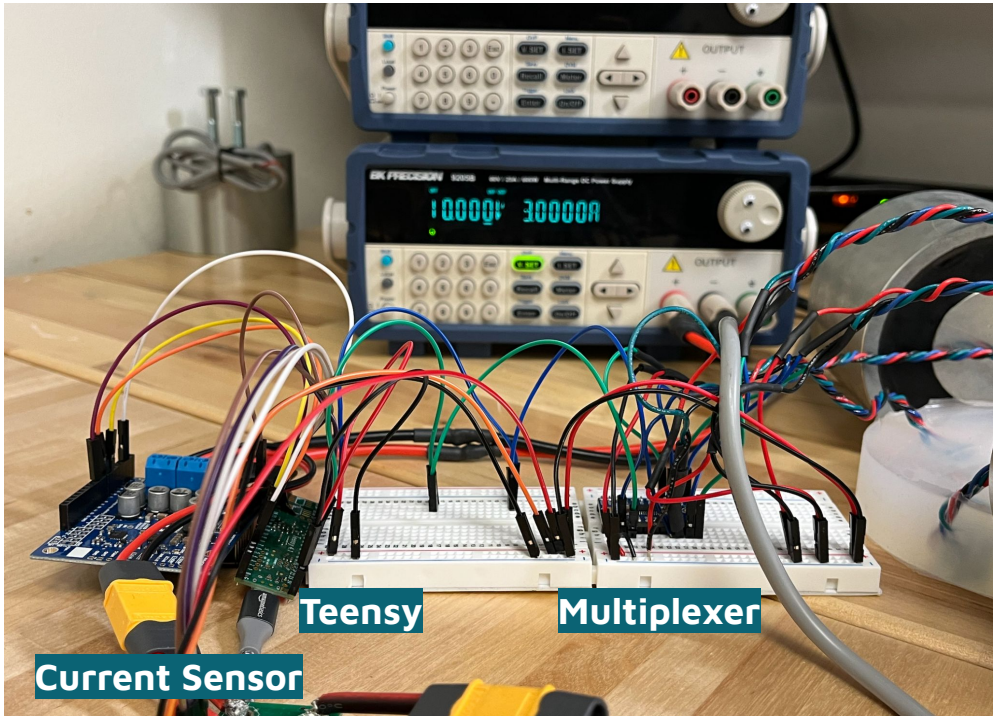
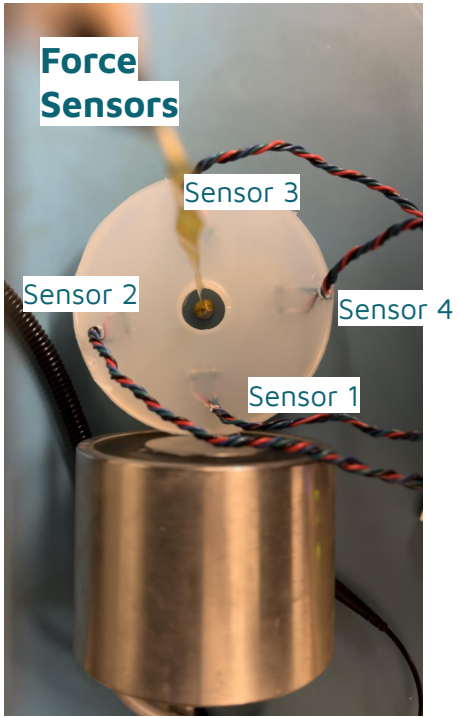
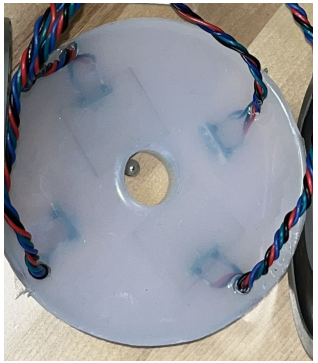
Control Architecture





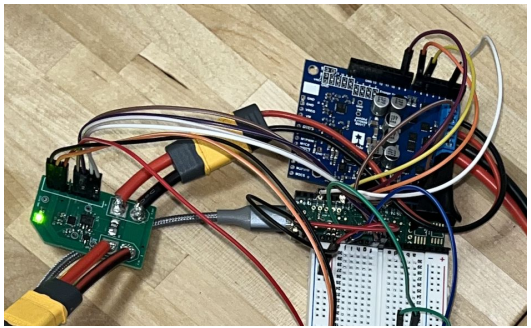
Control Architecture

HIGH LEVEL: doctor decides whether to collect biopsy sample.



MID LEVEL (training only): force sensors are used ensure that system acts safely.

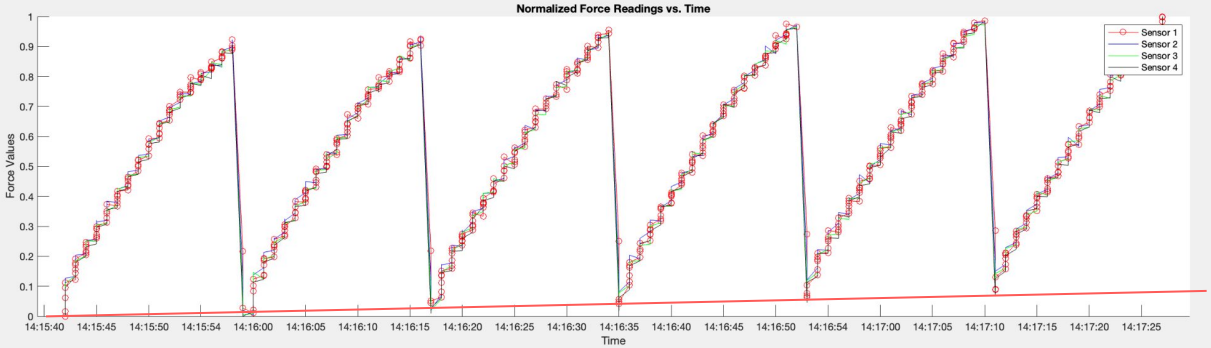
MID LEVEL: Teensy 4.1 uses position input to make sure it's going to the right place.

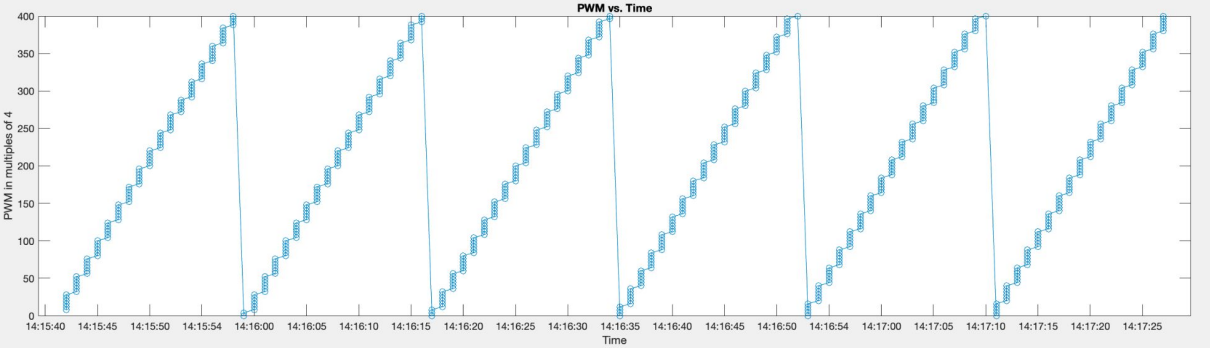


LOW LEVEL: current sensor on motor driver.

Force Consistency

Consistent, repeatable relationship to increased PWM





Sensor Drift Over Time

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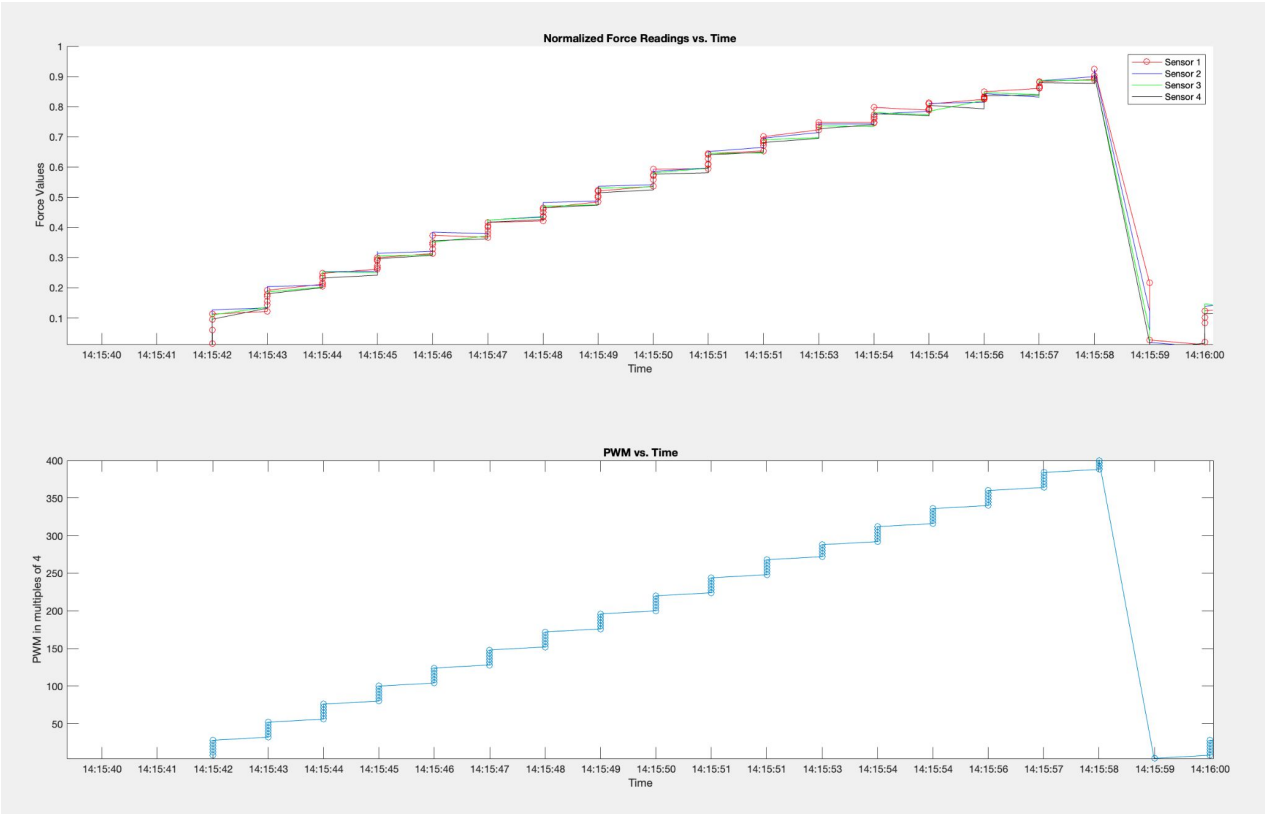
Force Consistency: a closer look

Sensor 1 placed closest to electromagnet



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Maximum Operational Distance: 8 inches from esophagus

	Sensor 1	Sensor 2	Sensor 3	Sensor 4
No current (control values)	0.66	0.59	0.53	0.52
2 inches	3.53	1.3	0.41	1.58
4 inches	1.22	0.91	2.1	2.53
8 inches	0.77	1.71	1.01	0.45
10 inches	0.67	0.58	0.61	0.52

10 inch difference ~= control

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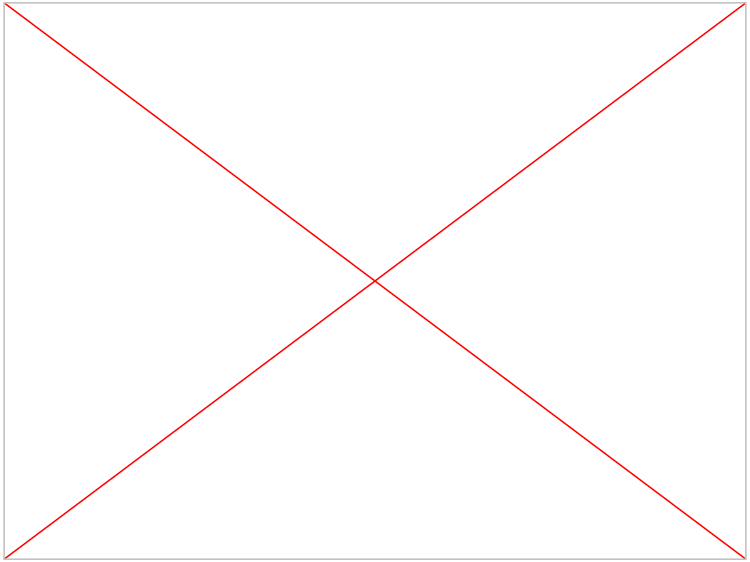
Demo



Future Directions

- With hobbyist hardware (~$600 budget), we can achieve pretty good control, and act at a reasonable distance from the body.
- Magnetic position tracking using hall effect sensors would be complex, but has been done before.
  - Magnetomicrometry (Taylor et al, MIT Media Lab)
- Electromagnetically guided release of capsule from edge of esophagus to rest position (to dampen momentum)
- Develop capsule communication electronics: standard camera, biopsy mechanism.
- Business model: this solution is safer, quicker, and potentially cheaper.
  - Less material in body
  - Portable device