Magnetic Pillcam Checkpoint Presentation

Mentors: Onder Erin, Axel Krieger
Students: Jack Yue, Mark Gonzales, Bharath Heggadahalli
3/29/2022

Project Background

PillCam

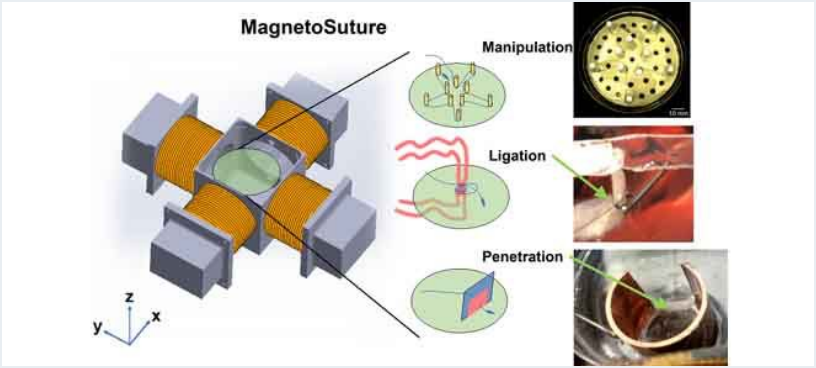
- A minimally invasive device developed as an alternative to endoscopic devices.
- No active robotic control on PillCam
  - Movement of a PillCam in GI-tract relies on passive body movements
- PillCam comes in a model with a camera on both ends and a model with a camera only on one end

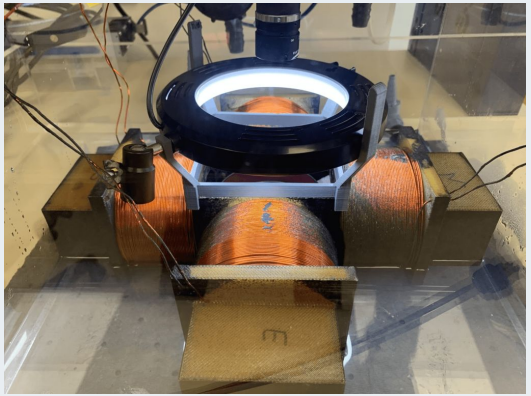
https://www.medtronic.com/covidien/en-us/products/capsule-endoscopy/pillcam-sb-3-system.html

Project Background

MagnetoSuture

- Technology that uses electromagnetic fields to control a magnet's motion
- Consists of four electromagnet coils (EMs) arrayed in a plane separated by 90 degrees
- EMs are controlled by wireless remote controller and individual coil current ranges from −20 A to 20 A
- Using this wireless remote controller, a needle or magnet can be moved in any direction in the space between the coils



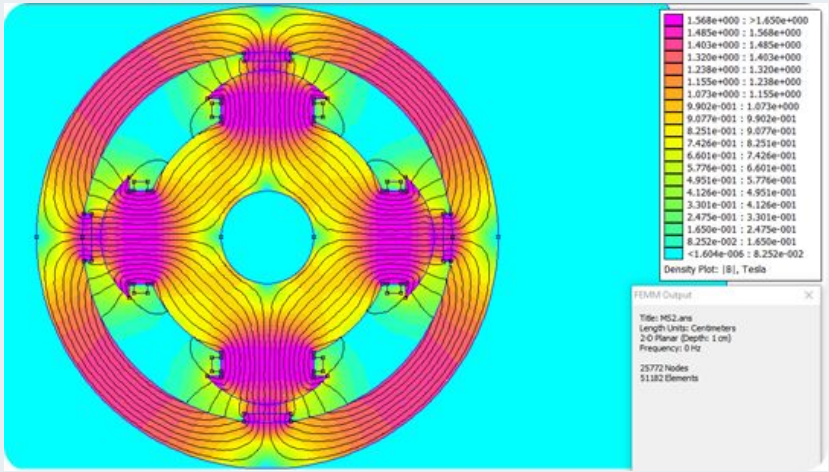


https://www.researchgate.net/publication/340723819_MagnetoSuture_Tetherless_Manipulation_of_Suture_Needle

Project Background

FEMM

- Finite Element Method Magnetics
- An open source finite element analysis software package for solving electromagnetic problems
- Can use it to simulate the magnetics relating to the MagnetoSuture device to get a better understanding of how the PillCam will interact with it



https://www.researchgate.net/publication/340723819_MagnetoSuture_Tetherless_Manipulation_of_Suture_Needle

Problem Statement

The PillCam's full potential is not fully exploited since its motion relies on passive body movements rather than being **actively controlled** by a user or AI.

Project Significance

- We believe that this would allow quicker and more specific image gathering process.
- This system would allow doctors to be able to examine specific areas of intestine without the need for the full scopic procedure.

Project Goals

- Create an **actively controlled PillCam** using magnets on the device and electromagnets to steer the PillCam
- Create an **exponentially stable** control scheme
- Allow the PillCam to be controlled by human at a controller

Figure 1: Electromagnetic Coil
https://www.d-pace.com/?e=265&w=news

Milestones

Phase 1a: Implementation of Magnet Placement in the PillCam (4/4)

Phase 1b: Implementation of IMU wireless data transfer (4/11)

Phase 2: Implementation of a Closed Loop Feedback Control that uses the changing magnetic fields to follow a certain trajectory (4/21)

Phase 3: Manuscript Work (5/2)

Dependencies

Dependency	Alternative Solution	Contact	Latest Date Before Project Delay	Status	Effect
Pillcam Procurement	Utilize other models currently in the lab	Onder Erin	3/5/2021	Resolved	Delay in integration with magnets
Magnet /IMU Procurement	Order from another company instead	Bharath Heggadahalli	3/11/2021	Resolved	Delay in integration with Pillcam
Functional Magnet Testing System	Test with individual magnets instead	Onder Erin	3/25/2021	Resolved	Alternative testing method of prototypes

IMU Progress

Due to chip shortage and small design space designing the wireless position communication took longer than expected.

We are working with the LPMS-B2 OEM which has self contained an IMU, microprocessor and Bluetooth transceiver.

We also have batteries to power this system that are not magnetic as this would throw off our movement

Further Progress: Add to system, Make waterproof

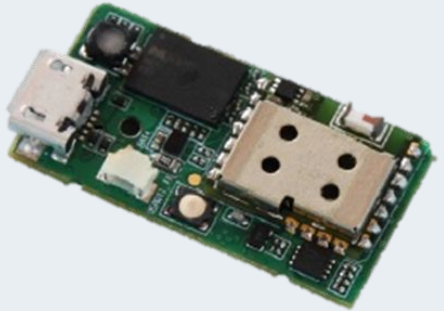


Figure 2: LPMS-B2 OEM

CAD Housing Progress

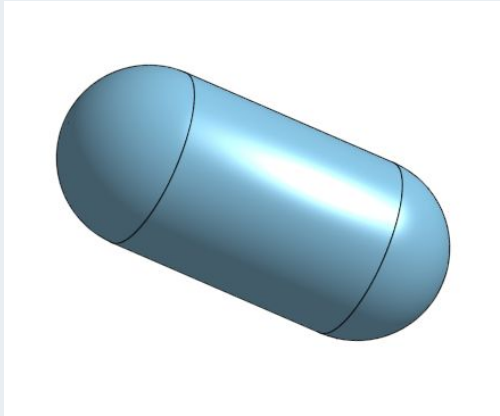


Figure 3: Pill Cam Model

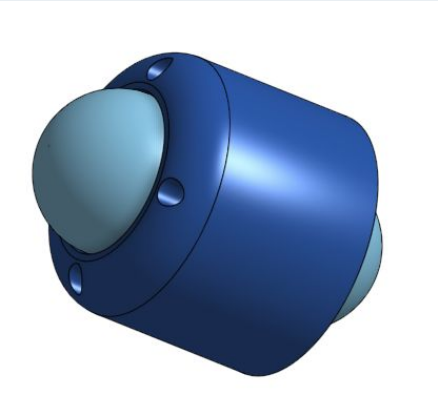


Figure 4: First Iteration Magnet Housing

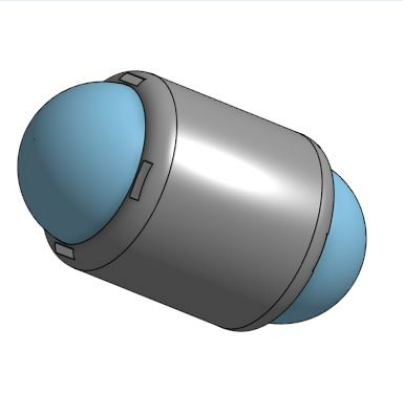


Figure 5: Slimmed Down Iteration

Figure 6: Printed Iterations

Testing

Figure 7: Models Compared to PillCam

Figure 8: Magnet Housing with PillCam

Figure 9: Magnets Around PillCam

Testing

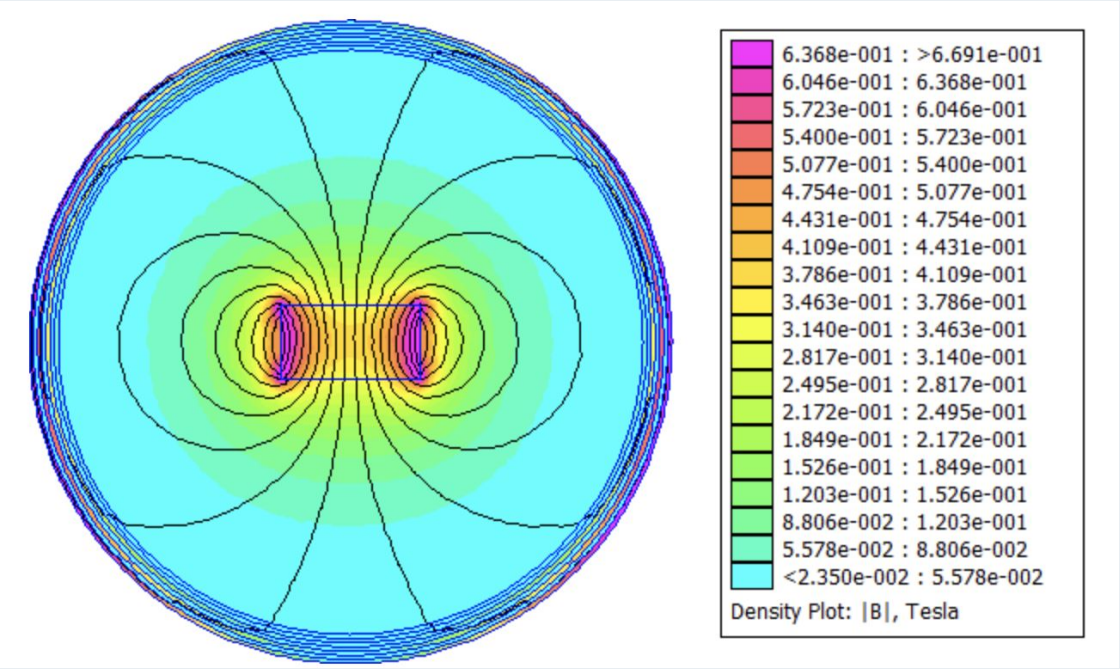
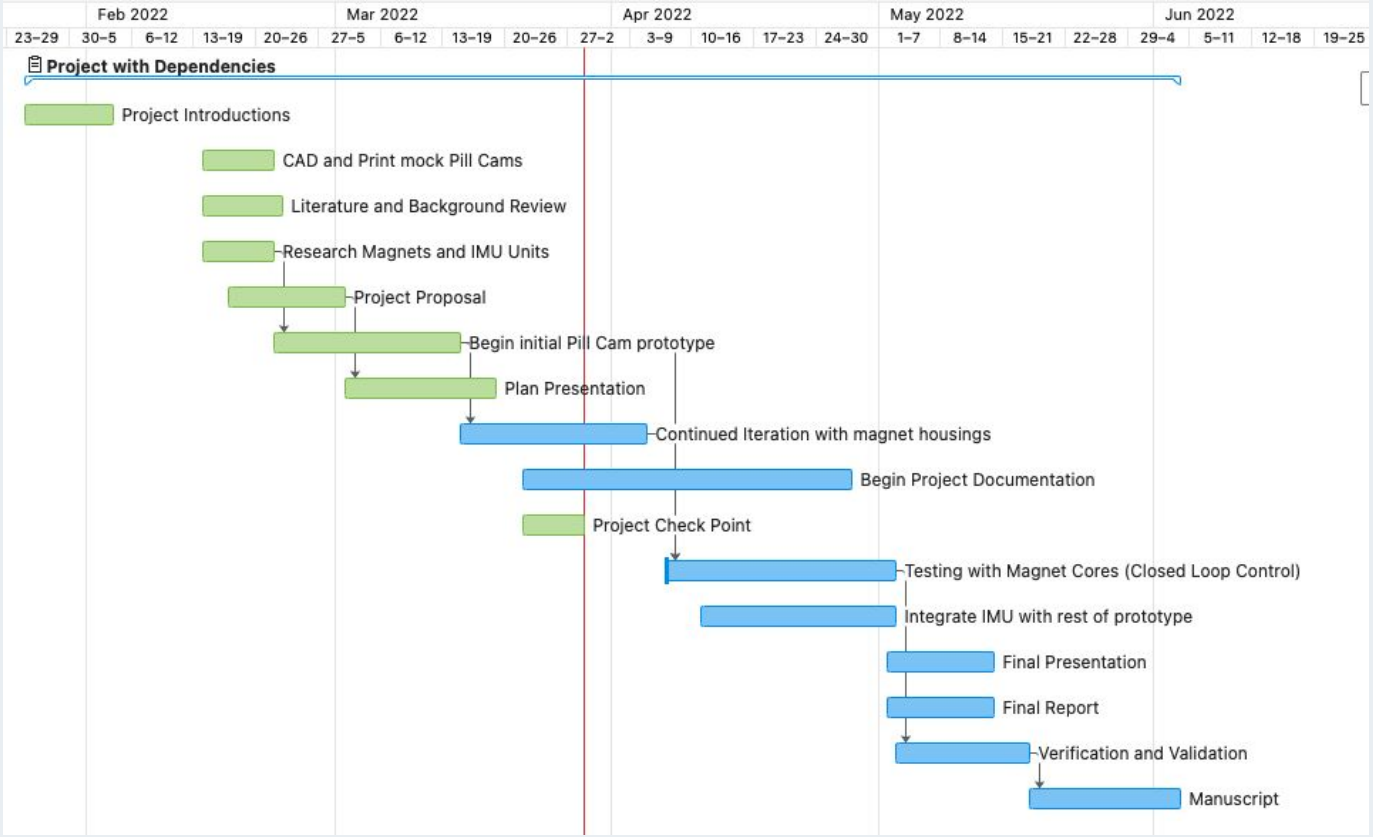


Figure 10: A neodymium iron boron cylindrical circle and simulating the magnetic field around it

Updated Gantt Chart



Documentations

- Documentation on current progress began in a shared google document categorized in a paper format
  - Background
  - Motivation
  - Designs
  - Testing
  - Results
  - Conclusions
- Furthermore, all code will be commented and CAD files organized based on design date and design objective

Deliverables

Minimum: Construction of Prototype Magnetic PillCam

- Dynamics Controllable by Magnetic Fields
- Wirelessly Sends Orientation and Position Data
- CAD Files, Electronics Layout and Design

Expected: Minimum + Closed loop control of system

- Implement a Control Scheme that would be able to follow any trajectory for all 6 degrees of freedom.
- The written design

Maximum: Expected + Publication

Next Steps...

- Continued Iteration with magnet housing for better movements
- Begin testing with the combined prototype for the simulated PillCam
- Integrate IMU Unit into the device
- Continue documentation

Reading List

- Vedaei, Seyed Shahim, and Khan A. Wahid. “A Localization Method for Wireless Capsule Endoscopy Using Side Wall Cameras and IMU Sensor.” Nature News, Nature Publishing Group, 27 May 2021, https://www.nature.com/articles/s41598-021-90523-w.
- “MPU-9250: TDK.” InvenSense, https://invensense.tdk.com/products/motion-tracking/9-axis/mpu-9250/.
- Adler, Samuel N, and Yoav C Metzger. “PillCam Colon Capsule Endoscopy: Recent Advances and New Insights.” Therapeutic Advances in Gastroenterology, SAGE Publications, July 2011, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3131168/.
- Koprowski, Robert. “Overview of Technical Solutions and Assessment of Clinical Usefulness of Capsule Endoscopy - Biomedical Engineering Online.” BioMed Central, BioMed Central, 1 Dec. 2015, https://biomedical-engineering-online.biomedcentral.com/articles/10.1186/s12938-015-0108-3.
- StatPearls. “Capsule Endoscopy.” StatPearls, StatPearls Publishing, 12 Aug. 2021, https://www.statpearls.com/ArticleLibrary/viewarticle/18834.