Magnetic PillCam

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Project Background

PillCam

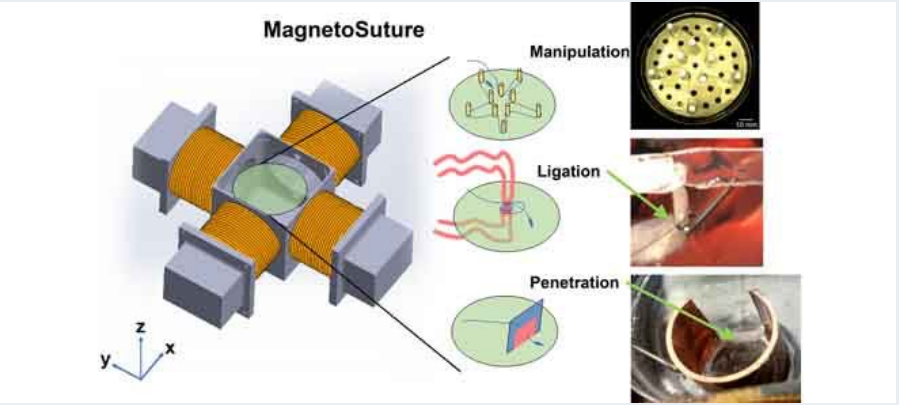
- A minimally invasive device developed as an alternative to endoscopic devices.
- No active robotic control on PillCam
  - Movement of a PillCam in GI-tract relies on passive body movements
- PillCam comes in a model with a camera on both ends and a model with a camera only on one end

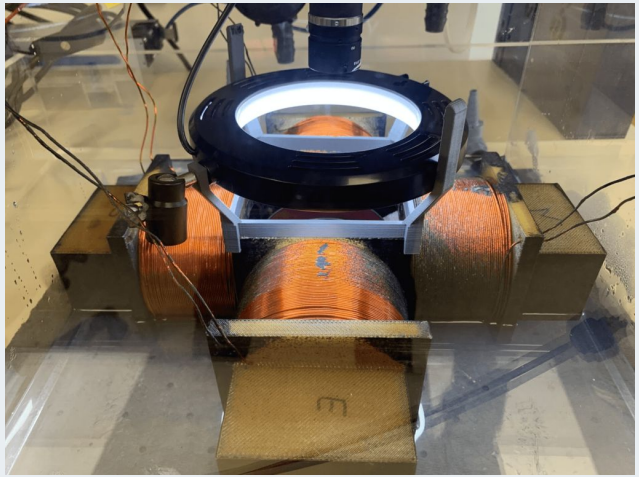
https://www.medtronic.com/covidien/en-us/products/capsule-endoscopy/pillcam-sb-3-system.html

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

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 Goals

- Create an **actively controlled PillCam** using magnets on the device and electromagnets to steer the PillCam
- Integrate the camera from the PillCam to control the movement of PillCam without external camera
- **Automate** the movement of PillCam using its camera

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

Technical Approach

- Mechanical
  - Analyze PillCam to identify most optimal placement of magnets
  - 3D print structure to add onto PillCam to hold magnets in a specific area
- Programming
  - Write code to calibrate the magnetic PillCam in the MagnetoSuture
  - Be able to control the movement of PillCam using only a controller changing the field strength from the coils
  - Integrate the camera from the PillCam to the code and control the PillCam while only using the PillCam camera
  - Automate PillCam movements using it's camera to map out a space around it

Milestones

Phase 1a: Implementation of Magnet Placement in the PillCam (3/14)

Phase 1b: Implementation of IMU wireless data transfer (3/21)

Phase 2: Implementation of a Closed Loop Feedback Control that uses the changing magnetic fields to follow a certain trajectory (4/11)

Phase 3: Manuscript Work (5/2)

Project Deliverables

Minimum: Development of a Magnetic PillCam

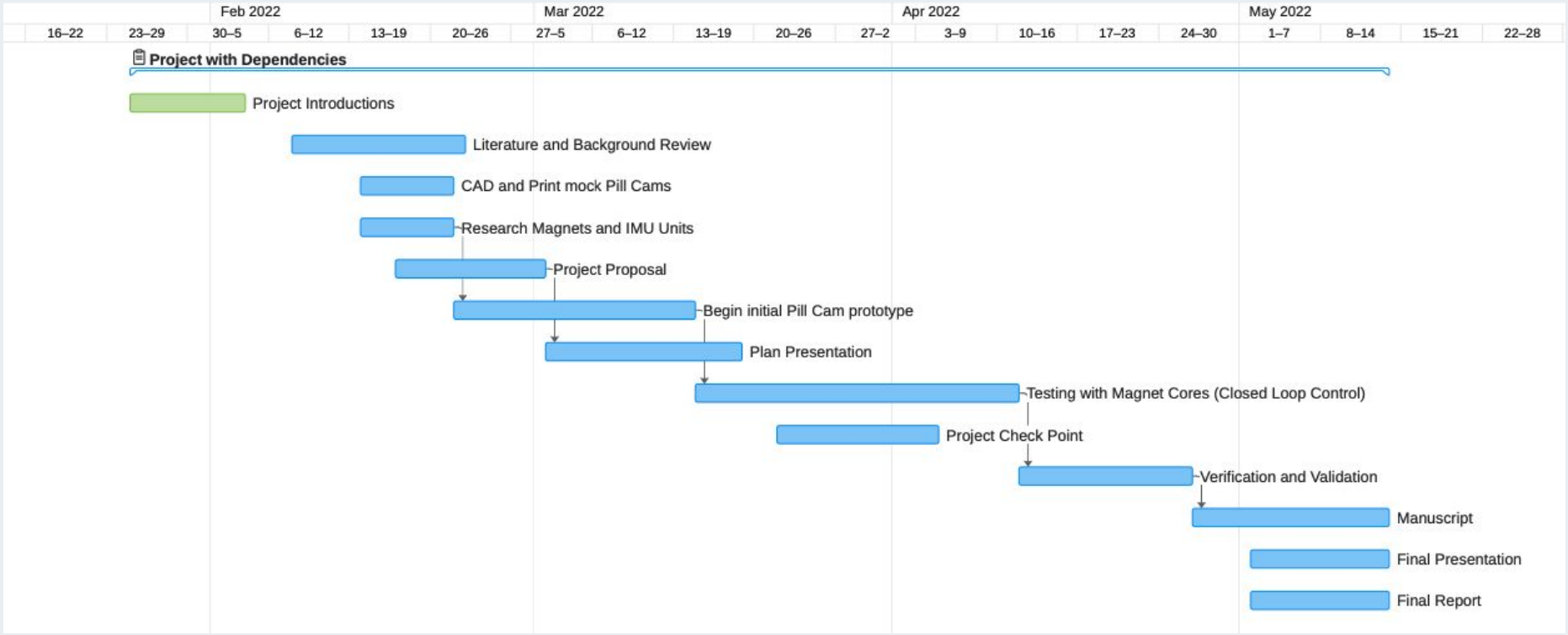
- Dynamics Controllable by Magnetic Fields
- Wirelessly Sends Orientation and Position Data

Expected: Minimum + Closed loop control of system

- Define a Control Scheme that would be able to follow any trajectory for all 6 degrees of freedom.

Maximum: Expected + Publication

Gantt Chart


Feb 2022
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27–2
3–9
10–16
17–23
24–30
1–7
8–14
15–21
22–28
Project with Dependencies
Project Introductions
Literature and Background Review
CAD and Print mock Pill Cams
Research Magnets and IMU Units
Project Proposal
Begin initial Pill Cam prototype
Plan Presentation
Testing with Magnet Cores (Closed Loop Control)
Project Check Point
Verification and Validation
Manuscript
Final Presentation
Final Report

Dependencies

Dependency	Solution	Contact	Expected Date	Status	Effect
Pillcam Procurement	Utilize other models currently in the lab	Onder Erin	3/5/2021	Ongoing	Delay in integration with magnets
Magnet /IMU Procurement	Order from another company instead	Bharath Heggadahalli	3/5/2021	Ongoing	Delay in integration with Pillcam
Functional Magnet Testing System	Test with individual magnets instead	Onder Erin	3/25/2021	Not Started	Alternative testing method of prototypes

Project Management

- All CAD designs will be shared with Onshape
- Code will be shared via github
- Other documents will be shared on shared Google Drive
- Weekly team meetings with mentors every Monday from 5-6pm
- Communication with mentor through email and slack

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.