Magnetic Field Steering System

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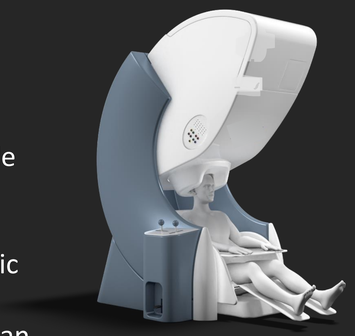
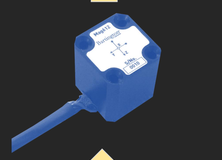
Background

- Current functional brain imaging technologies are invasive (ECoG) or do not provide high spatial or temporal resolution (EEG)
- MEG is the measurement of magnetic fields generated by neural activity in the brain
- MEG allows higher resolution brain imaging in a more flexible and non-invasive way
- Prevalent background magnetic fields in the frequency range of neural activity necessitates an external null environment for accurate MEG measurements

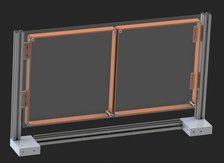
Current MEG Systems



Software and Integration



Ambient Field
+
Generated Field



Magnetometer I/O (Ni-DAQmx)

Signal Pre-Processing
- Signal smoothing
- Convert voltages to magnetic flux densities

Logging
- Save unprocessed data for analysis

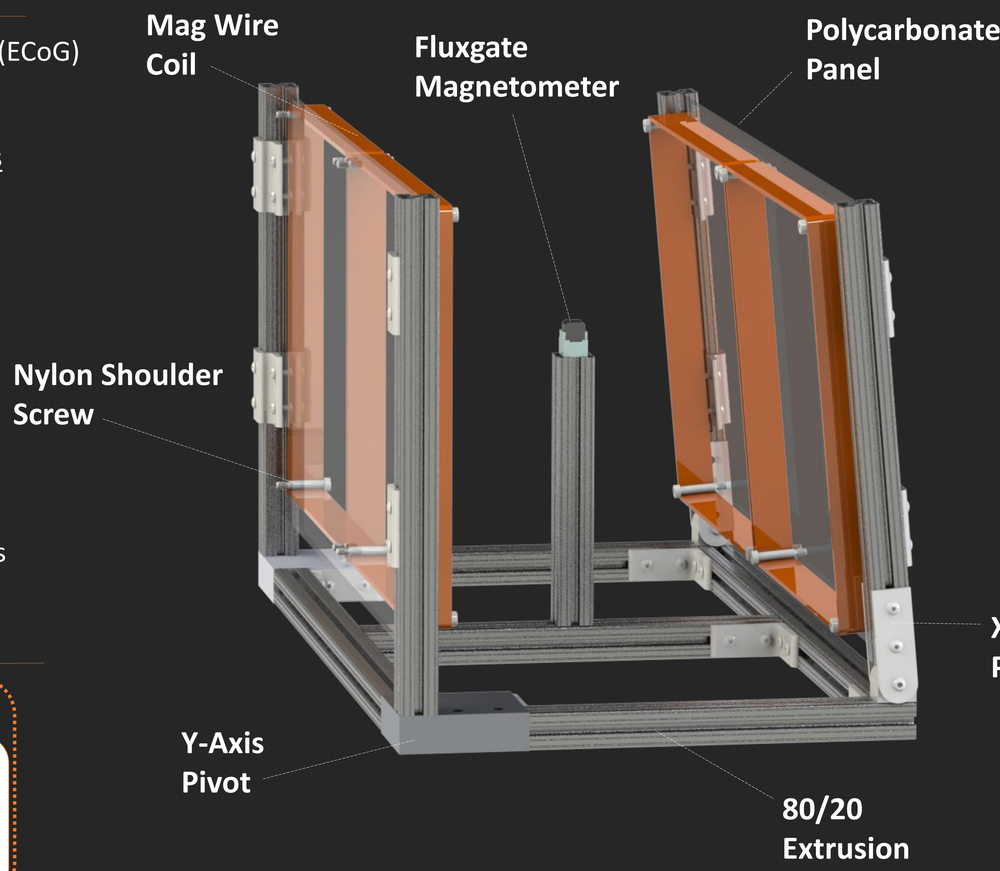
Simulation and Optimization
- Simulate generated magnetic fields
- Simulation can be configured for an arbitrary coil layout
- Determine the optimal current on each coil using convex optimization, minimizing the field at a specified point in the control volume

Analysis Toolkit
- Automated diagnostics, detects defective coils
- Interface with external USGS data for magnetometer calibration
- Visualization tools
- Frequency analysis

Signal Post-Processing
- Convert currents to voltages for coil drivers

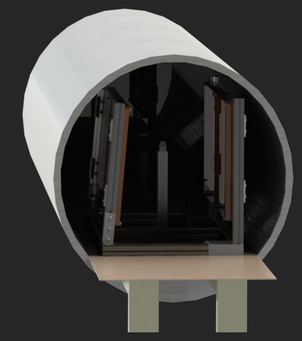
Logging
- Save currents solutions for analysis

Coil Driver I/O (Ni-DAQmx)



Objectives

- Design, fabricate, and test a magnetic field cancellation system that reads the input from a fluxgate magnetometer and cancels the magnetic field along multiple axes inside an enclosed volume
- Proof of concept: 2 panels of 2 coils each that create a magnetic field zero between them for a 1µT background field range within a shielded mu-metal tube
- Generate and validate a simulation modeling the magnetic field strength produced by the system at any location, at a frequency of 10 Hz
- Successfully operate in a cross-functional team

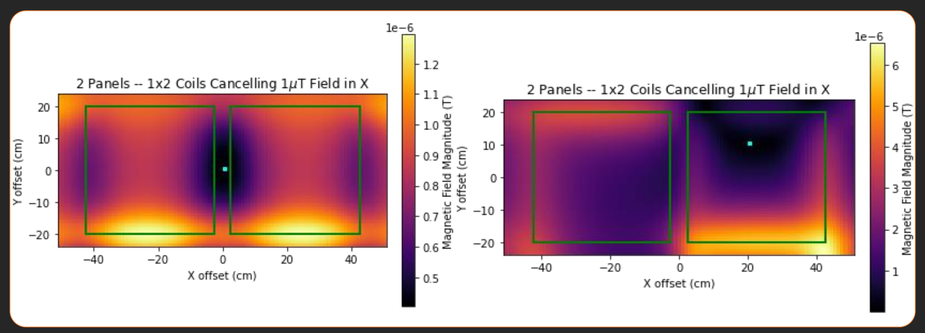


Test Setup
- 30” diameter
- Mu-Metal is non-permeable
- Filtration of Earth’s magnetic field creates a more controlled test environment

Testing and Results

Test Plan
1. Overall Functionality Test
2. Simulation Output Test
3. Open-Loop Cancellation in the Z-axis
4. Open-Loop Cancellation in the X-axis
5. Mechanical Tolerance Test: +/- 5.0° deflection about X and Y axes

Simulation Tests
- Control loop solving for a static 1 µT field in the X direction
- Optimization around the blue point
- Darker areas indicate low magnetic field



Conclusions

Objectives Achieved
- Test assembly is adapted for angular deflection tolerance testing in two directions
- Panel framework and support assembly facilitates testing within the limited access of the Mu-Metal tube
- Simulation results provide quantitative and qualitatively informative results

Future Improvements
- Further testing and simulation comparisons are primary objectives
- Include control over field gradients as well as scalar values
- Implement dynamic cancellation and sensor motion tracking
- Long term goal of full-scale assembly

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