Localization of Micro Devices Based on Gradient and Magnetic field

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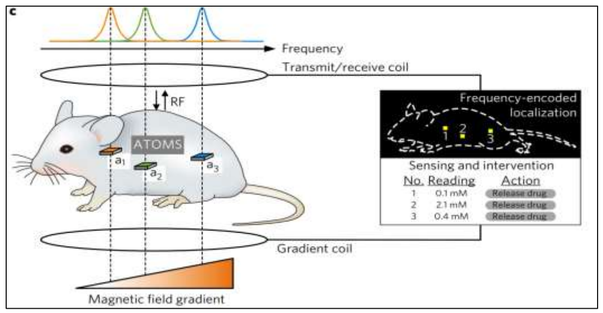
Introduction

Micro medical devices have proven to be useful when it involves the treatment and diagnosis of human disease, however, methods of localization such as radio frequency or magnetic fields are flawed in their ability to precisely determine their location and communicate with them. By following principles of the nuclear magnetic renaissance, and designing micro devices whose output frequency shifts with the magnetic field, it's hypothesized that this method of localization will be an improvement, allowing for accurate controlling, and advanced precision.

Objective & Impact of Prof. Manuel Monge's Research

The objective of Professor Manuel Monge's research is to further improve the methods of localizing micro devices. By refining the use of magnetic fields, micro devices can be controlled with extreme precision, further expanding their ability to treat and diagnose human disease. The objective of this project is to generate a gradient magnetic field in one direction, based on the structure of the helmholtz coil. The coil will be simulated in MATLAB, then 3D modeled in ANSYS for more precise results. These results would be helpful to Professor Monge's research for refining the magnetic field in one axis.



Monge, Manuel, et al. "Localization of microscale devices in vivo using addressable transmitters operated as magnetic spins." Nature biomedical engineering 1.9 (2017): 736-744

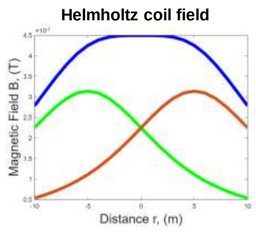
Skills Learned

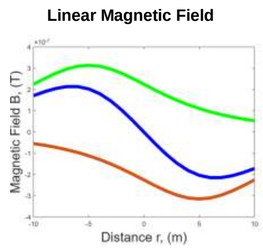
MATLAB

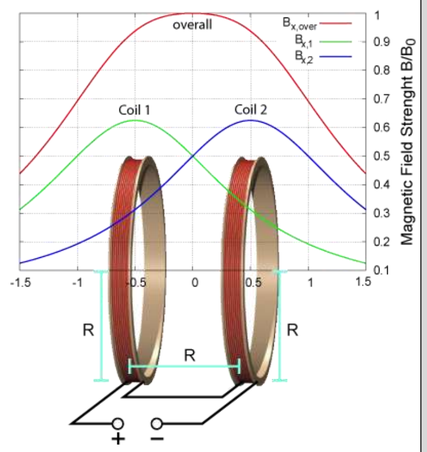
First step was to simulate a linear magnetic field through a model of a helmholtz coil.

```
r = 10;
% Constant
pi = 3.1415926;
u0 = 4*pi*1e-7;
% Assumet 1A current given
I = 1;
x = -10:1:10;
n = 5;
% Calculating the magnetic field
B1 = u0.*I.*n.*r.^2./(2.*(r.^2+(x+r./2).^2).^(3/2));
% Plot
plot(x,B1,'linewidth',5);
hold on
% Adding axis name and title of the graph
xlabel('Distance r, (m)');
ylabel('Magnetic Field B, (T)');

B2 = u0.*I.*n.*r.^2./(2.*(r.^2+(x-r./2).^2).^(3/2));
plot (x, B2,'linewidth',5);
hold on

Bt = B1 + B2;
plot (x, Bt,'linewidth',5)
```

For the set of coils, the radius and distance between them is 10cm. It is able to generate a constant field that passes through the coils. By rotating the phase of input current of the second coil and tuning distance, a linear magnetic field is created in the religion between the two coils, as shown on the right.





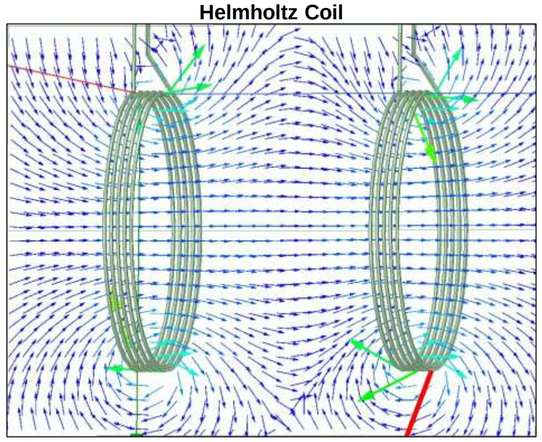


Magnetic field of two helmholtz coils, Virtuelle Experimente, <https://virtuelle-experimente.de/en/b-feld/b-feld/helmholtzspulenpaar.php>

Ansys

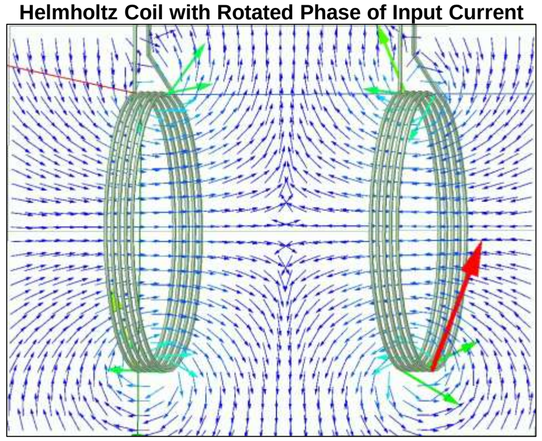
Through ANSYS, I was able to create a more precise model of the helmholtz coil. This software allowed me to calculate values from within the linear field, and plot them on a graph.

Helmholtz Coil



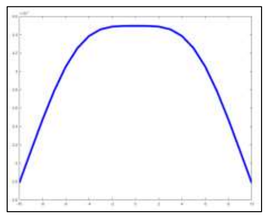
Constant field passing through the two currents. Each coils has 5 turns, and the distance between each coil is 0.5cm. Arrows in graph represent magnetic field vector.

Helmholtz Coil with Rotated Phase of Input Current

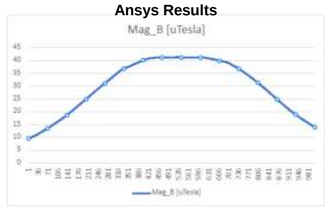


As modeled through MATLAB, rotating the phase of input current for the second coil allows for a linear magnetic field in the region between the two coils.

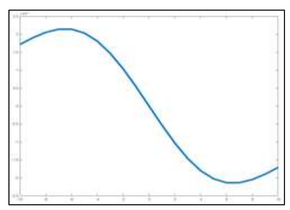
MATLAB Results



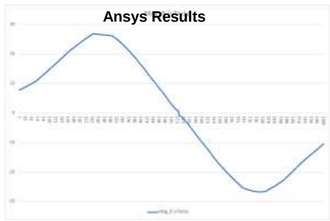
Ansys Results



MATLAB Results



Ansys Results



My STEM Coursework

SHINE introduced me to a topic I knew very little about, yet helped me understand the importance of my STEM coursework. In this project, I applied my prior programming knowledge and 3D modeling skills to understand linear currents. SHINE has also taught me about programs I was not familiar with such as Matlab and ANSYS. SHINE has given me the opportunity to use what I had learned in the classroom while also introducing me to new subjects.

Next Steps

Next year I plan on taking Computer science and calculus to further improve my understanding of softwares such as MATLAB and its equations. Eventually I plan on majoring in electrical engineering. Until then I will further improve my understanding of physics so I can apply that knowledge to future courses.

Acknowledgements

I would like to thank Professor Manuel Monge for allowing me to participate in his lab. I would also like to thank my mentor Hongxiang Gao for his patience when teaching me about a new concept. I would also like to thank Dr. Katie Mills for this special opportunity. FInally, thanks to Monica Lopez, my center mentor Masae Yamanaka and my parents for their support.