MNR Lab
Medical Micro & Nano Robotics

GUC
German University in Cairo
الجامعة الألمانية بالقاهرة

Design and Development of An Omnidirectional Electromagnet

Development of an electromagnetic system that generate variable dipole-moment magnitude and orientation without moving parts is of great interest for motion control of helical microrobots at a distance. In this work, we expand on the Omnimagnet of Petruska *et al.* An Omnimagnet is an omnidirectional electromagnet comprising a spherical ferromagnetic core inside of three orthogonal nested solenoids. It generates a magnetic dipole field with both a variable dipole-moment magnitude and orientation with no moving parts. The focus in this project is on the design and fabrication of the Omnimagnet and the integration of this electromagnet to the HeliMag system.

Objective

Generating variable dipole-moment magnitude and orientation usually necessitate the integration of a permanent magnet to a motor to provide rotating dipole fields. In 2014, Petruska *et al.* presented a design of An Omnimagnet [1, 2] that eliminate he moving parts, while generating variable dipole moment. In this project, we would like to modify our HeliMag system [3] by integrating two Omnimagnets instead of the DC motors and the permanent magnets. Once this integration is achieved, HeliMag will be used to control helical microrobots in three dimensional space.

Tasks

- Development of the system shown in Fig. 1;
- Modeling and control of the Omnimagnet;
- Control of the magnetic field that is generated using the omnidirectional electromagnets;
- Synchronization of the magnetic fields generated using the two omnidirectional electromagnets.

Materials

- Six DC motors for the 2 delta robots;
- Six linear slides to develop the delta robots;
- Spherical magnets for the omnidirectional electromagnets;
- A magnetic field sensor and a finite element model;
- A feature tracking algorithm.

PREREQUISITES

Students are expected to have a working knowledge of control theory, differential equations, linear systems, statics, kinematic and dynamics. Familiarity with programming, especially with Matlab and C++.

OTHER NOTES

This project will involve a weekly meeting with the instructors and progress reports have to be prepared. All reports should be written in academic paper format.

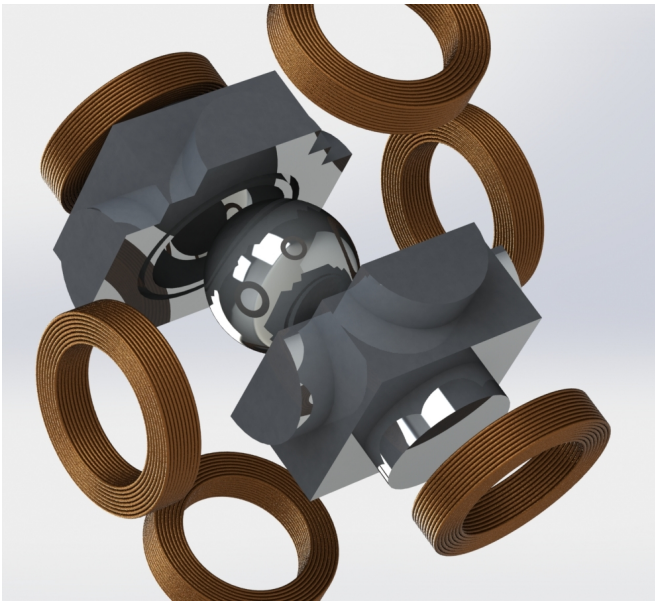

Figure 1. Assembly of the Omnimagnet.

1. References

[1] A. J. Petruska and J. J. Abbott, "Omnimagnet: An Omnidirectional Electromagnet for Controlled Dipole-Field Generation ," *IEEE Transactions on Magnetics*, vol. 50, no. 7, 8400810, July 2014.

[2] N. D. Nelson and J. J. Abbott, "Generating two independent rotating magnetic fields with a single magnetic dipole for the propulsion of untethered magnetic devices," in *Proceedings of the IEEE International Conference on Robotics and Automation (ICRA)*, pp. 4056–4061, Seattle, Washington, USA, May 2005.

[3] M. E. Alshafeei, A. Hosney, A. Klingner, S. Misra, and I. S. M. Khalil, "Magnetic-Based motion control of a helical robot using two synchronized rotating dipole fields," in *Proceedings of the IEEE RAS/EMBS International Conference on Biomedical Robotics and Biomechatronics (BioRob)*, pp. 151-156, São Paulo, Brazil, August 2014.