MNR Lab
Medical Micro & Nano Robotics

GUC
German University in Cairo
الجامعة الألمانية بالقاهرة

An Electromagnetic-Based Robotic System for Minimally Invasive Interventios

This project addresses the integration of HeliMag system and a KUKA robot arm. HeliMag enables the generation of rotating magnetic fields to provide locomotion for helical microrobots. The KUKA robot arm will provide feedback using a camera that is installed to its end-effector. The main focus in this project is on the integration and the implementation of closed-loop control of helical microrobot under microscopic and vision guidance.

Objective

Microrobot can navigate throughout the cardiovascular system of humans and reach deep seated regions inaccessible by conventional and minimally invasive surgeries. This level of control necessitates the integration of an electromagnetic system with an open configuration such as the HeliMag system (Fig. 1) and a robotic arm to provide visual feedback using a microscopic vision system.

Tasks

- Development of an electromagnetic system that consists of two delta robots and OmniMagnets (Fig. 1);
- Precise motion control of helical microrobots in 3D space;
- Motion control of the KUKA robot arm and the integration of a camera to its end-effector;
- Realization and development of the system shown in Fig. 1;

Materials

- Helical microrobots, DC motors, linear motion stages, and a camera;
- Two OmniMagnets;
- 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.

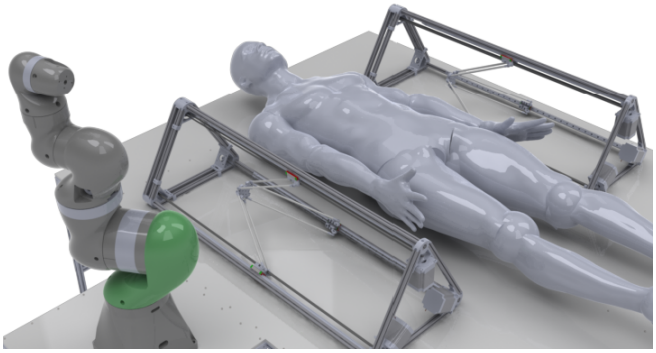

Figure 1. A conceptual image of the HeliMag and a KUKA robot arm. HeliMag provide helical propulsion, whereas a camera at the end-effector of the KUKA robot provide visual feedback of the microrobot.

1. References

[1] M. P. Kummer, J. J. Abbott, B. E. Kartochvil, R. Borer, A. Sengul, and B. J. Nelson, “OctoMag: an electromagnetic system for 5-DOF wireless micromanipulation," *IEEE Transactions on Robotics*, vol. 26, no. 6, pp. 1006-1017, December 2010.

[2] I. S. M. Khalil, R. M. P. Metz, L. Abelmann, and S. Misra, “Interaction force estimation during manipulation of microparticles," in *Proceedings of the IEEE International Conference of Robotics and Systems (IROS)*, pp. 950-956, Vilamoura, Portugal, October 2012.

[3] I. S. M. Khalil, F. van den Brink, O. S. Sukas, and S. Misra, “Microassembly using a cluster of paramagnetic microparticles," in *Proceedings of the IEEE International Conference on Robotics and Automation (ICRA)*, pp. 5507–5512, Karlsruhe, Germany, May 2013.