MNR Lab
Medical Micro & Nano Robotics

GUC
German University in Cairo
الجامعة الألمانية بالقاهرة

Magnetic Control of Sperm Cells

Usefulness of targeted therapy using magnetic drug carriers (magnetic microbead, nanobeads, and microrobots) is limited by the relatively small projection distance of the magnetic field gradients of electromagnetic systems. For instance, localization of a few magnetic nanobeads can be only achieved using relatively high magnetic field gradient that can only be generated using a modern magnetic resonance imaging system. This problem can be overcome by the development of self-propelled microrobots to use the magnetic field source only for steering not for driving (projection distance of the magnetic field is greater than that of the magnetic field gradient). This self-propulsion is accomplished by the integration of a microorganism (a sperm cell) and a magnetic microbead (to allow for the directional control).

Objective

The focus of this project is on the development of a biocompatable self-propelled magnetic microrobot, which we refer to as Sperm-Driven Microrobot (SDM). SDMs will be developed by studying the interactions between sperm cells and magnetic microbeads at low Reynolds number regime. The primary focus of the project will be on achieving successful coupling between the sperm cells and the magnetic microbeads by chemical treatment of the surface of the microbeads. In addition, we intend on controlling the motion of SDMs using an electromagnetic system in the 3D space using microscopic feedback and feature tracking algorithm.

Tasks

There are several challenges inherent to the develop- ment of an SDM:

- Fabrication of magnetic nanoparticles;
- Achieving successful coupling between motile sperm cells and the magnetic nanoparticles;
- Separation of the SDMs from the mixture of sperm cells and magnetic microbeads using microfluidic chan- nels and external magnetic fields;
- Localization and control of the SDMs in three-dimensional (3D) space using an electromagnetic system.

Materials

- Paramagnetic microparticles (Micromod Partikeltechnologie GmbH, Rostock-Warnemuende, Germany) and motile sperm cells;
- An electromagnetic system;
- Microfluidic channels;

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++.

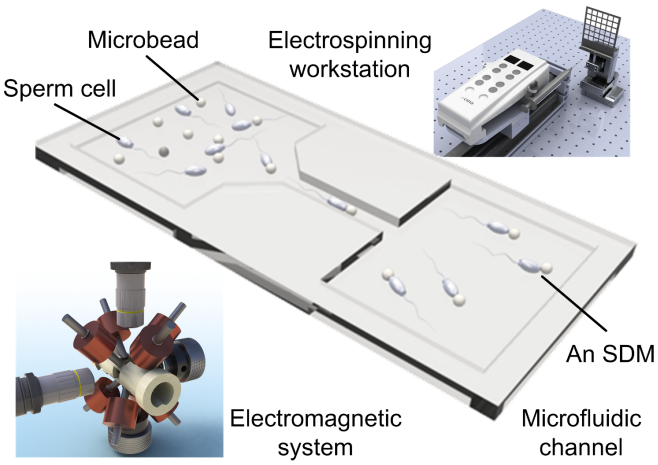

Figure 1. Schematic representation of the separation of the SDM from the mixture of sperm cells and magnetic mi- crobeads. The separation is done using a microfluidic chan- nel with 2 connected chambers under the influence of the controlled magnetic field lines. The magnetic fields are gen- erated using an electromagnetic system (bottom-left corner), whereas the microbeads are fabricated using electrospinning (top-right corner). An SDM is separated from the mixture by orienting the magnetic fields parallel to the channel between the two chambers.

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.

1. References

[1] I. S. M. Khalil, V. Magdanz, S. O. Sanchez, O. G. Schmidt, and S. Misra, "Biocompatible, accurate, and fully autonomous: A sperm-driven micro-bio-robot," *Journal of Micro-Bio Robotics*, vol. 9, no. 3-4, pp. 79-86, August 2014.

[2] V. Magdanz, M. Medina-Sánchez, L. Schwarz, H. Xu, J. Elgeti, and O. G. Schmidt, "Spermatozoa as functional components of robotic microswimmers", *Advanced Materials*, vol. 29, no. 24, June 2017.