MNR Lab
Medical Micro & Nano Robotics

GUC
German University in Cairo
الجامعة الألمانية بالقاهرة

Fabrication and Characterization of Robotic Sperms using Molecularly Imprinted Polymers

We experimentally demonstrate that using oscillating weak magnetic fields, a sperm-shaped microrobot (which we refer to as MagnetoSperm) can swim using flagellar propulsion and slide on a surface under water. The sperm morphology allows the MagnetoSperm to mimic the locomotion mechanism of a living sperm cell. The MagnetoSperm is designed and developed with a magnetic head and a flexible tail to provide a magnetic dipole moment and propulsion, respectively. The head oscillates under the influence of controlled oscillating weak magnetic fields (5 mT). This oscillation generates a thrust force in the flexible tail, and hence allows the MagnetoSperm to overcome the drag and friction forces during swimming and sliding on a surface under water, respectively. Open-loop and point-to-point closed-loop control of the MagnetoSperm are accomplished using an electromagnetic system under microscopic image guidance. This motion control is done in two cases, i.e., swimming in water and sliding on a surface.

Objective

In this study, we develop a sperm-shaped microrobots using molecularly imprinted polymers that contains drugs in their polymer matrix.

Tasks

- Fabrication and control of MagnetoSperm;
- Modeling of MagnetoSperm using resistive-force theory.

Materials

- MagnetoSperms have to be fabricated using electrospinning;
- An electromagnetic system for magnetic actuation;
- Verification of the model via a comparative study with the experimental results.

PREREQUISITES

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

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, A. F. Tabak, A. Klingner, and M. Sitti, "Magnetic propulsion of robotic sperms at low-Reynolds number," *Applied Physics Letters*, vol. 109 (033701), July 2016.

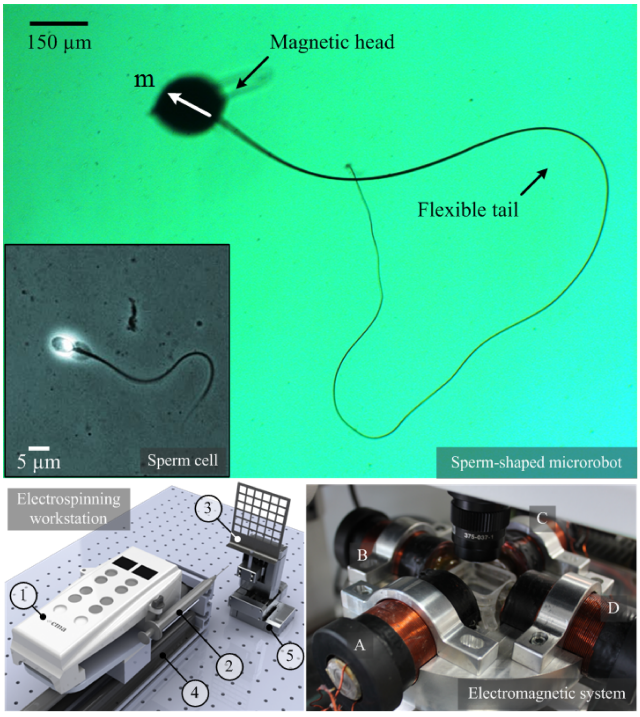

Figure 1. A sperm-shaped microrobot is fabricated using electrospinning. This microrobot consists of a microbead and an ultra-fine fiber that resemble the morphology of a sperm cell. The microbead contains iron oxide nanoparticles and provides magnetic dipole moment ($\mathbf{m}$), whereas the fiber provides propulsive force when oscillating magnetic fields are applied. These fields are generated using an orthogonal configuration of electromagnetic coils (bottom-right inset). This workstation consists of a Syringe pump (1), a syringe needle (2), a grounded collector (3), a linear motion stage (4), and a cartesian robot with 3 degrees-of-freedom (5). High voltage is supplied between the needle and the collector (6).