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

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 (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).