MNRLab
Medical Micro & Nano Robotics

GUC
German University in Cairo
الجامعة الألمانية بالقاهرة

On The Transition Between Planar and Helical Wave Propulsion

Sperm cells swim by a beating tail that undergoes different patterns such as planar wave propulsion and helical wave propulsion. In this work, we will investigate the transition between these two locomotion mechanisms in Low Reynolds number environment. Sperm shaped microrobots will be fabricated and controlled using helmholtz coils that are available in MNRLab. Rotating and oscillating magnetic fields will be used to achieve the transition between the helical and planar wave propulsion.

Objective

We will fabricate sperm shaped microrobots which we refer to as MagnetoSperms using electrospinning. The ability to enforce a transition between planar and helical locomotion using dynamic magnetic fields is the objective of this work. Motion of MagnetoSperms will be tracked using high speed cameras and the influence of the external magnetic field on the beating flagellum will be characterized.

Tasks

- Fabrication of MagnetoSperms using electrospinning (Fig. 1);
- Motion control of MagnetoSperm using helmholtz coils;
- Characterization of the helical propulsion using rotating magnetic fields;
- Characterization of the planar propulsion using oscillating magnetic fields;
- Investigation of the transition between planar and helical wave propulsion.

Materials

- MagnetoSperms are fabricated using the electrospinning workstation in MNRLab;
- Helmholtz coils are avaliable in MNRLab;
- High speed cameras are required to track the motion of the MagnetoSperm and its beating tail.

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.

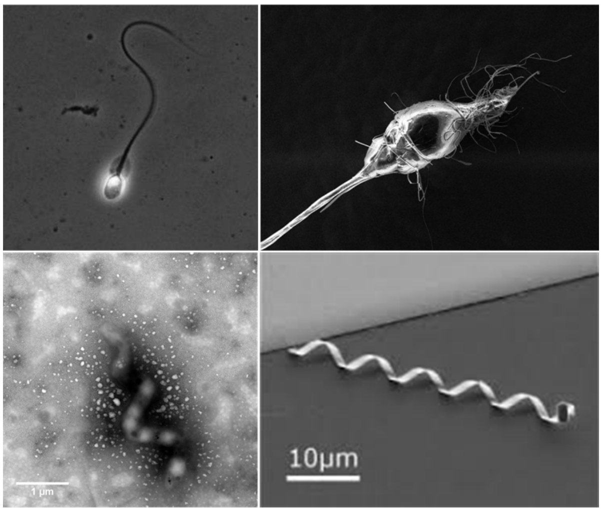

Figure 1. Sperm cells undergo various swimming patterns, whereas *E. Coli* bacteria swim by helical propulsion of the flagella bundle.

1. References

[1] A. W. Mahoney and J. J. Abbott, “Control of untethered magnetically actuated tools with localization uncertainty using a rotating permanent magnet," in *Proceedings of the IEEE RAS/EMBS International Conference on Biomedical Robotics and Biomechatronics (BioRob)*, pp. 1632-1637, Rome, Italy, June 2012.

[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.