MNR Lab
Medical Micro & Nano Robotics

GUC
German University in Cairo
الجامعة الألمانية بالقاهرة

Development of a Robust Feature Tracking Algorithm for Magnetotactic Bacteria in a Non-Uniform Flow-Field

This work addresses the tracking and control of magnetotactic bacteria (MTB) using a magnetic-based manipulation system. We present a technique to track the motion of MTB in the three-dimensional space. Our feature tracking algorithm is based on subtraction of the backgrounds of two input videos. These videos are provided by our three-dimensional magnetic system. This background subtraction allows the tracking algorithm to be insensitive to a variety of factors, such as lighting changes and perspective distortions. In addition, our feature tracking algorithm allows us to track MTB within a micro fabricated maze with a channel width of 10 μm. Our algorithm enables us to track MTB with an average length of 5 μm. A model of the electromagnetic system is developed and utilized in the realization of a control system. The motion control system allows the MTB to reach reference positions within the maze at a velocity of 8 μm/s and within a mregion-of-convergence of 10 μm in diameter. Furthermore, the tracking software provides a technique to track bacteria in the three-dimensional space.

Objective

This project provides a robust feature tracking algorithm in the three-dimensional (3D) space to track MTB [1]. The tracking algorithm is insensitive to distortions such as exposure changes, background structures and image noise. This insensitivity is mainly caused by background subtraction. Some other techniques which are used in the feature tracking algorithm are thresholding, eroding and dilation. Increasing bandwidth is accomplished by a region of interest in which most of the image processing is done [2]. In addition, a motion control system is implemented for the manipulation of MTB in the three-dimensional space. The motion control system uses the position of the MTB which is provided by our feature tracking algorithm.

Tasks

- Culturing of magnetotactic bacteria;
- Tracking of the motion of MTBs in 2D space;
- Motion control of the MTBs based on the developed feature tracking algorithm;

Materials

- Capillary tubes have to be ordered (VitroCom, VitroTubes 3520-050, Mountain Lakes, USA);
- An electromagnetic system and the Ginkgo chip are avaliable;
- A feature tracking algorithm is available;
- A syringe pump is available.

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++.

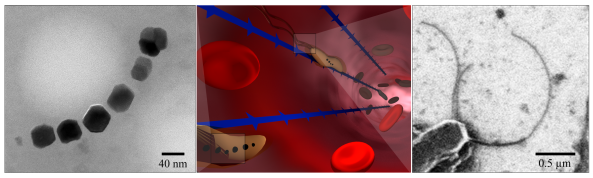

Figure 1. Conceptual image of magnetotactic bacteria (MTBs) steered under the influence of external magnetic fields in a blood vessel. MTBs align themselves along the magnetic field lines (blue lines) and move by rotating their helical flagella. The alignment is achieved using magnetite (Fe_3O_4) nano-crystals that are contained inside the cell.

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] H. A. Hassan, M. Pichel, T. Hageman, L. Abelmann, and I. S. M. Khalil, "Influence of the magnetic field on the two-dimensional control of *magnetospirillum gryphiswaldense* strain MSR-1," in *Proceedings of the IEEE/RSJ International Conference of Robotics and Systems (IROS)*, pp. 5119–5124, Daejeon, Korea, October 2016.

[2] I. S. M. Khalil, A. F. Tabak, K. Sadek , D. Mahdy, N. Hamdi, M. Sitti, "Rubbing against blood clots using helical robots: modeling and *in vitro* experimental validation," *IEEE Robotics and Automation Letters*, vol. 2, no. 2, pp. 927-34, April 2017.

[3] A. Hosney, J. Abdalla, I. S. Amin, N. Hamdi, and I. S. M. Khalil, "*In vitro* validation of clearing clogged vessels using microrobots," in *Proceedings of the IEEE RAS/EMBS International Conference on Biomedical Robotics and Biomechatronics (BioRob)*, pp. 272-277, Singapore, June 2016.