MNR Lab
Medical Micro & Nano Robotics

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الجامعة الألمانية بالقاهرة

Development of a 3D Electromagnetic System with Automatic Focusing

This work addresses the tracking and control of microrobots using a magnetic-based manipulation system. We will present a technique to track the motion of microrobots in 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. A model of the electromagnetic system is developed and utilized in the realization of a control system.

Objective

In this study we will develop a feature tracking algorithm that would allow for the tracking of the motion of microrobotic systems in three-dimensional space. This feature tracking algorithm will depend on the input video streams provides using two cameras. The cameras are mounted on two motion stages to provide autofocusing.

Tasks

- Fabrication of a 3D electromagnetic system
- Tracking of microrobots in 2D and 3D spaces;
- Control of microrobots in 3D space;

Materials

- Paramagnetic microparticles and nanoparticles (Micromod Partikeltechnologie GmbH, Rostock-Warnemuende, Germany);
- An electromagnetic system;
- Cameras;
- Control system;
- A feature tracking algorithm.

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.

1. References

[1] J. J. Abbott, Z. Nagy, F. Beyeler, and B. J. Nelson, "Robotics in the small, part I: microbotics," *IEEE Robotics and Automation Magazine*, vol. 14, no. 2, pp. 92-103, June 2007.

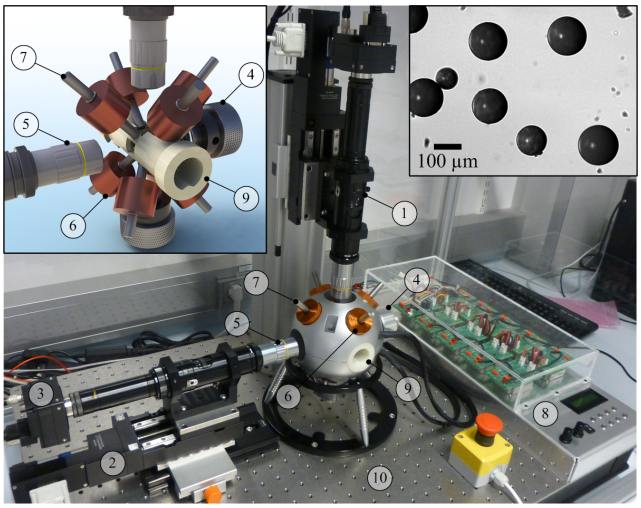

Figure 1. Magnetic system for the wireless motion control of paramagnetic microparticles in three-dimensional space. The magnetic system allows for autofocusing using two microscopic systems (1) and two linear motion stages (2). Cameras (3) with resolution and frame rate of 1024×1024 and 120 fps, respectively, are used to provide visual feedback. Illumination can be adjusted manually using 2 knobs (4). Magnification can be adjusted using the microscopic systems and objectives (5). The magnetic system consists of 8 electromagnetic coils (6) with iron cores (7). Current is supplied to the electromagnets using current amplifiers (8). A holder (9) is used to position a water reservoir at the center of the electromagnetic arrangement. The magnetic system is mounted on a vibration isolation table (10). The upper-left inset shows a rendered model of the iron-core electromagnets, reservoir holder, illumination knobs and objectives. The upper-right inset shows a microscopic image of paramagnetic microparticles in water.

[2] C. Pawashe, S. Floyd, E. Diller, and M. Sitti, "Two-dimensional autonomous microparticle manipulation strategies for magnetic microrobots in fluidic environments," *IEEE Transactions on Robotics*, vol. 28, no. 2, pp. 467-477, April 2012.

[3] L. Dong and B. J. Nelson, "Tutorial-Robotics in the small part II: nanorobotics," *IEEE Robotics and Automation Magazine*, vol. 14, no. 3, pp. 111-121, September 2007.