MNR Lab
Medical Micro & Nano Robotics

GUC
German University in Cairo
الجامعة الألمانية بالقاهرة

Characterization of the Magnetic Force of Microrobotic Systems

This work investigates the utilization of microparticles for the wireless sensing of interaction forces in magnetic based manipulation systems. The proposed force estimation approach allows for using microparticles in sensing the interaction forces at hard-to-reach regions to avoid the mechanical and electronic complexities associated with physical force sensors. Based on the velocity of the microparticle and the applied currents at each of the electromagnets of the magnetic system, an interaction force observer is designed to estimate the contact forces between the microparticle and a soft-tissue simulant with different elasticities. Experimentally, a magnetic system is utilized to steer a microparticle towards a soft-tissue simulant to carry out force sensing. The experimental results show that forces in the range of nano-Newton can be estimated without nano-force sensors. The estimated interaction forces due to this contact can be used either in sensing and diagnosis applications, or in the realization of a force control system.

Objective

This work analyzes an approach for the wireless magneticbased estimation of the interaction forces between microparticles and their surrounding environment. This approach avoids the mechanical and electronics complexities associated with force sensors. In addition, it provides microparticles or microrobots with wide range of applications since no extra force sensors have to be embedded to their structure. The analyzed approach demonstrates the possibility of estimating contact forces in the range of few nano-Newton up to tens of nano-Newton.

Tasks

- Development of an electromagnetic system with micro force sensing probe (Fig. 1);
- Motion control of a cluster of paramagnetic microparticles in 2D space;
- Measurement of the magnetic force using a micro force sensing probe.

Materials

- Microforce sensing probe (FT-S100 Microforce Sensing Probe, FemtoTools AG, Buchs, Switzerland);
- Paramagnetic microparticles and nanoparticles (Micromod Partikeltechnologie GmbH, Rostock-Warnemuende, Germany);
- An electromagnetic system and 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.

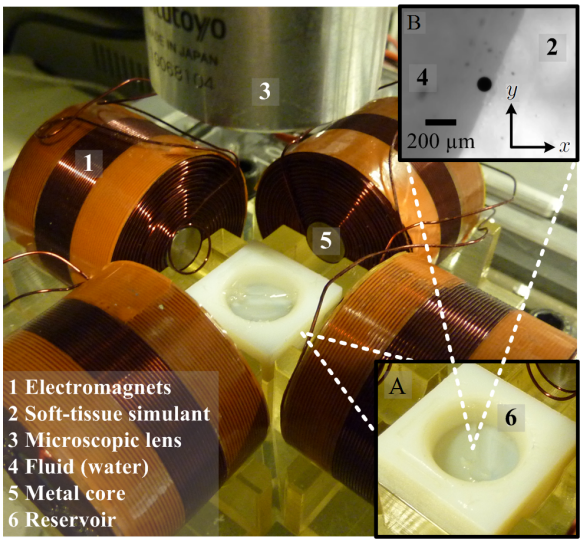

Figure 1. Magnetic system developed for the wireless control of microparticles. The microparticle is used to sense the interaction forces with a soft-tissue simulant. Inset A shows a reservoir which contains a fluid and a soft-tissue simulant that possesses the mechanical properties of the biological tissue. Inset B shows a 100 μm spherical microparticle in contact with the soft-tissue simulant.

1. References

[1] S. Fahlbusch and S. Fatikow, "Force sensing in microrobotic systems–an overview," in *Proceedings of the IEEE International Conference on Electronics, Circuits and Systems (ICECS)*, vol. 3, pp. 259-262, Lisboa, Portugal, September 1998.

[2] 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.

[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.