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Multi-actuating Binary Magnetic Nanorobots

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RCEU 2023 Project Proposal

Project Title

Multi-actuating Binary Magnetic Nanorobots

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I. Project Description

Nanorobots have great potential for in-body treatment at the cellular level. However, the degrees of freedom and the multitasking functionality decrease as the scale decreases compared with macroscopic robots. The dynamic behavior of nanorobots with multitasking functionality remains challenging at the nanoscale. In particular, nanorobots with independent locomotion capabilities for reaching small vascularly regions which are not easily accessed by other methods. Electromagnetic field are used to manipulate the position of colloidal particles, but tuning their configuration for multitasking requires variable polarization at different conditions. Magnetic nanoparticles with different shapes and magnetic anisotropy are promising candidates for building tunable nanorobots. They provide multiple responses that can be used for directional and orientational actuation in response to both the applied field and the environmental changes.

In this project, we will model the dynamic response of nanorobots composed of binary magnetic nanoparticles with different shapes and magnetic properties. We will perform Brownian dynamic simulations to investigate the dynamic response of magnetic nanorobots under the influence of time-varying magnetic fields. As a result, we will settle the fundamentals to develop an algorithm for controlling the multi-actuation of binary magnetic nanorobots (nanites).

II. Student Duties, Contributions, and Outcomes

a. Specific Student Duties

The student must perform the numerical simulations, plot the results, analyze the data, and write reports on a regular basis during the summer. For that purpose, the student will have a computer station where to perform the simulations and a hard drive to store/backup the data. Additionally, the student must review the current literature in the field regularly under the guidance of the Professor and the graduate students. Furthermore, the student will present his/her results three times during the summer in group meetings. It is expected to submit two reports during his/her stay during the summer, a midterm report, and a final report.

b. Tangible Contributions by the Student to the Project (10% of Review)

It is expected that the student publishes his/her final results in Perpetua, and present his/her results in the poster session during the fall at UAH. The extended version of the final report, in collaboration with the graduate student and under the supervision of the Faculty, will be published in a peer-review Journal.

c. Specific Outcomes Provided by the Project to the Student (30% of Review)

The student will learn Brownian dynamic simulation of three-dimensional anisotropic objects as a function of position and orientation. The student will learn computational tools (e.g., Unix/Linux, Matlab, Fortran, and Wolfram Mathematica) relevant for different computational research work. Additionally, the student will learn important concepts about translational and rotational Brownian

motion of colloidal particles. The student will learn how to analyze, plot, and calculate the mean-swimming-velocity of the structure. The student will work in a research environment, participating in research discussions, and collaborating with graduate students for writing a peer review article. The interaction with other graduate students will be a valuable experience for future undergrad or graduate research experiences.

III. Student Selection Criteria

This project is open to highly motivated students at all academic ranks from the college of Sciences and the College of Engineering.

IV. Project Mentorship *(30% of Review)*

The Professor will train the student daily during the first two weeks (or longer) of the project to ensure the student learns and handles the computational tools required to accomplish the project. After that, the student will meet the Professor every other day to present one or two slides about his/her research results achieved during the previous days. The Professor will advise the next steps in the research to be accomplished before the next meeting, i.e., the Professor will ensure the student success in the undergraduate summer project with permanent guidance as to any other graduate student. Additionally, the daily informal conversations with the Professor every time that he steps in the laboratory or the undergraduate student requires it to overcome any research problem. Furthermore, the student will interact with a Ph.D. student and a Master's student while the research project is completed. Fully trained graduate students will be the first contact persons in the computational laboratory to answer his/her questions related to the research topic.