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NANO HIGHLIGHT
NIRT: Bio-Nano-Robotic Systems Using Viral Protein Nano-Motors

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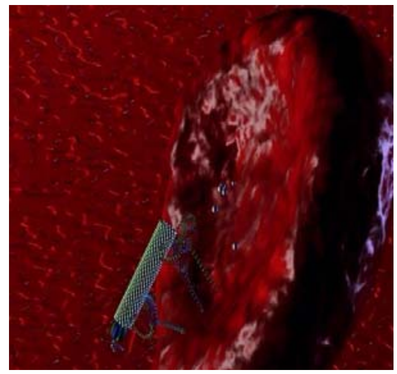

FIGURE 1: A "nanorobot" flowing inside a blood vessel, finds an infected cell. The nanorobot attaches to the cell and projects a drug to repair or destroy the infected cell.

The recent explosion of research in nano-technology, combined with important discoveries in molecular biology has created a new interest in biomolecular machines and robots. The main goal in the field of biomolecular machines is to use various biological elements — whose function at the cellular level creates a motion, force or a signal — as machine components that perform the same function in response to the same biological stimuli but in an artificial setting [1, 2]. In this way proteins and DNA could act as motors, mechanical joints, transmission elements, or sensors. If all these different components were assembled together they could potentially form nanodevices with multiple degrees of freedom, able to apply forces and manipulate objects in the nanoscale world, transfer information from the nano- to the macroscale world and even travel in a nanoscale environment. The advantage of using nature's machine components is that they are highly efficient and reliable. Such bionanorobotic devices will hopefully be part of the arsenal of future devices and instruments that can be used in many applications including medicine where they will: 1) perform operations, inspections and treatments of diseases inside the body, and 2) achieve ultra-high accuracy and localization in drug delivery, thus minimizing side effects. Figure 1 shows an idealized rendition of a biomolecular nanorobot repairing an infected cell in a blood vessel. The bionanorobot will be able to attach to the infected cell alone, and deliver a drug that can treat or destroy just the infected cell, sparing the surrounding healthy cells.

In this project, we are studying the development of Viral Protein Linear (VPL) nanomotors and their integration as actuators in bio-nano-robotic systems. In order to infect new cells, several viruses employ proteins on their surface that undergo changes in their structural conformation in order to promote the fusion of the viral membrane with the cellular membrane. This change is due to the pH change associated with the vicinity of the cell. Given similar conditions, it is proposed in this project to use this conformational change to produce VPL motors. In the first year of this project we have focused our computational and experimental studies in the influenza virus and its hemagglutinin protein. The project consists of three research phases: 1) Performance of computational studies to develop models and design procedures that will predict and optimize the performance of the proposed bio-nano motors and systems [3]; 2) Execution of experimental studies to demonstrate the validity of the proposed concepts, models and design methodologies; and 3) Establishment of the interface of the proposed protein motors with other biomolecular components such as DNA joints and carbon-nanotube rigid links so that complex, multi-degree of freedom machines and robots powered by VPL motors are formed.

References

1. Mavroidis C. and Dubey A., “From Pulses to Motors”, *Nature Materials*, Vol. 2, No 9, pp. 573-574, 2003.
2. Mavroidis C., Dubey A., and Yarmush M., "Molecular Machines", *Annual Reviews of Biomedical Engineering*, Vol. 6, 2004.
3. Dubey A., Sharma G., Mavroidis C., Tomassone S. M., Nikitczuk K.P., Yarmush M.L., "Computational Studies of Viral Protein Nano-Actuators," *Journal of Computational and Theoretical Nanoscience*, Vol. 1, No. 1, pp. 18-28, 2004.
4. For further information about this project link to http://www.bionano.neu.edu or email Dr. Mavroidis at: mavro@coe.neu.edu