SEMTE

seminar

Micro-/Nano-Scale Systems Engineering: A Bio-inspired Approach

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abstract

Through evolution, nature produces nearly endless biological diversity. Underlying principles of biological systems in nature, especially those at the micro-/nano-scale, have been and will continue to be an important source of inspiration for micro-/nano-scale systems engineering with applications not only in disease prevention, diagnosis and treatment, but also in building energy-efficient and sustainable engineered systems. The goal of this talk is to demonstrate, through illustration of our recent work on naturally occurring nanoparticles and energy-efficient propulsion mechanisms of swimming microorganisms, that a bio-inspired engineering approach may offer plenty opportunities for innovations in micro-/nano-scale systems engineering. The opportunities create tremendous emerging areas for engineering research, and raise many challenges for training future engineers.

The first part of this talk is about naturally occurring and bio-inspired nanoparticles. Biological systems can produce many different types of naturally occurring nanocomponents (NONs), including nanoparticles, nanofibers, and nanotubes. The NONs can be easily found in air, soil, water, mineral composites, and biological systems. Some NONs are produced by biological systems to carry out specific functions. Many others are simply generated from biological systems as a result of physical or chemical interactions of biological systems within their natural environments. We will show how naturally occurring nanoparticles from ivy, a carnivorous fungus, and tea can be used in drug delivery, cancer immunochemotherapy, and tissue engineering.

For swimming micro-organisms in low nutrient environments, their flagella spend a significant percentage of the total available energy to budget on movement. It is believed that a high energy efficiency of swimming was selected over the course of evolution. However, it is not clear how micro/nano-scale dynamics, control and morphology of the flagella may contribute to the overall system performance, especially in terms of efficiency of propulsion. In the second part of the talk, we will discuss how *Giardia,* a common human parasite, employs a unique flagella-based swimming mechanism for energy-efficient propulsion, and why the curved swimming trajectories are more energy efficient than linear trajectories for *whirligig beetles*, which have been claimed in the literature to be one of the highest measured for a thrust-generating apparatus within the animal kingdom.

In the end of the talk, we will share our recent research on bio-inspired nanoparticles, nano-adhesive, ***(cont.)***

(abstract cont.) nanocomponent-based micro-/nano-robots, and bio-inspired energy-efficient propulsion systems for large-scale swimming robots. We would conclude that the keys for bio-inspired engineering lie in the ability to understand the underlying principles of biological systems, and extract of the essential biological functions or properties for inspiration. We propose a three-step approach, including the elucidation of unique functions and properties of biological systems, the identification and extraction of working principles at the micro-/nano-scale, and the enhancement as well as integration of these principles for synergistic development of engineered systems.

biosketch

Mingjun Zhang received the D.Sc. degree from Washington University in St. Louis, and the Ph.D. degree from Zhejiang University, P. R. China. He also earned MS degrees in Bioengineering and Electrical Engineering from Stanford University. After working 7 years in life science instrumentation industry in the Silicon Valley, he started his academic career as an Associate Professor of Biomedical Engineering at the University of Tennessee, Knoxville, in 2008. Since then, his group has made several original contributions on naturally occurring nanoparticles, energy-efficient propulsion mechanisms, and bio-inspiration for micro-/nano-scale systems engineering. Dr. Zhang's long-term research goal is to build energy-efficient, sustainable nanoparticle-based systems to interface with biological systems, to be utilized in medicine, and bio-inspiration to scale-up for swimming robots. His research benefits from the group's unique expertise on integration of multiple nano-instrumentation platforms, and systems theory. His current research focuses on bio-inspired nanoparticles, and flagella-based energy-efficient propulsion. Dr. Zhang has been received a Young Investigator from ONR, and the Early Career Award by the IEEE Robotics and Automation Society.

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