Engineering Bacteria-Enabled Autonomous Systems for Parallel Manipulation of Nanoscale Objects

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This talk will focus on developing swarms of *living machines* that can autonomously produce, transport, manipulate, or assemble a large number of micro/nano-objects in parallel. Wild-type and engineered bacteria have long been used in the biotechnology industry to produce biopolymers, biodegradable plastics, biomineralized composites, and inorganic nanomaterials. Combining methods from microrobotics, microfluidics, and synthetic biology, the opportunity to use the material synthesis capability of bacteria for autonomous construction of micro/nano-structured objects will be discussed. Steps towards this ultimate goal including micro/nano-scale load transport, sorting, programmable emergent behavior (e.g., pattern formation) of bacteria and bio-hybrid swarms, and rational engineering of biochemical machinery of bacteria will be discussed. First, the effect of nanoparticle load size and quantity on the motile behavior of bacteria will be presented. Spontaneous formation and microfluidic-enabled directed transport of bacteria-nanoparticle assemblies for simple, cost-effective, and high throughput sorting of nanoscale particles of dissimilar surface properties will be discussed next. Finally, a multiscale computational model that integrates population dynamics with genetic circuit dynamics to enable examination of the performance robustness of engineered bacteria swarms with respect to growth rate, biochemical circuit sensitivity, and the population’s initial size and spatial structure will be described. Quantitative tuning of microbial systems’ performance through rational engineering of synthetic ribosomal binding sites will also be discussed. This modeling framework can serve as an insightful tool for the predictive design of bio-hybrid microrobotic swarms as programmable multi-agent systems with tunable and robust responses in the context of specific applications.

Brief Bio:

Prof. Bahareh Behkam obtained her B.Sc. degree from Sharif University of Technology, and her M.Sc. and Ph.D. degrees from Carnegie Mellon University, all in Mechanical Engineering. She is an associate professor of Mechanical Engineering with affiliate appointments in the School of Biomedical Engineering and Sciences and the Macromolecules Innovation Institute at Virginia Tech and the Wake Forest Baptist Comprehensive Cancer Center. Dr. Behkam is the director of the MicroN BASE Laboratory at Virginia Tech. Her current research interests include the development of bio-hybrid microrobotic systems for cancer therapy, interfacial mechanics of pathogen-biomaterial interactions, and cell migration in multi-cue environments. She was a recipient of the Virginia Tech’s College of Engineering Outstanding New Assistant Professor Award in 2012 and the National Science Foundation CAREER award in 2015. Her research work has been awarded the 2012 Adhesion Society Peeble Award, the 2013 ASME-NEMB Aline Best Paper Award, 2014 ASME-NEMB Best Poser Award, and 2018 MARSS Best Conference Paper Award. She is an associate editor for the Journal of Micro-Bio Robotics.