Control of Swarm Robotic Systems for Coverage and Manipulation Tasks

Spring M. Berman
Autonomous Collective Systems Laboratory
School for the Engineering of Matter, Transport, and Energy
Arizona State University

Abstract: Novel low-cost autonomous robots such as micro-aerial vehicles are currently being developed as a result of recent advances in computing, sensing, actuation, power, control, and 3D printing technologies. Massive populations, or swarms, of such robots have the potential to collectively perform tasks over very large domains and time scales, succeeding even in the presence of failures, errors, and disturbances. In this talk, I present a rigorous framework for reliably controlling the population dynamics of robotic swarms to achieve desired collective behaviors using only local sensing and common broadcast information. This framework is applied to tasks that require (a) target spatial distributions of robot activities (such as data collection) over a domain; (b) target robot allocations around the boundaries of regions or structures; and (c) cooperative manipulation of heavy payloads. The approach incorporates stochastic, deterministic, and hybrid stochastic-deterministic models at different levels of abstraction that describe the robots' roles, task transitions, motion, and manipulation dynamics. I will describe methods for designing the robot control policies to be robust to environmental variations and to mimic observed behaviors of ants performing collective transport tasks. Potential applications for this control approach include environmental monitoring and exploration, search-and-rescue, disaster recovery, security operations, automated construction and manufacturing, and even biomedical imaging and drug delivery at the nanoscale.