

Flocks and Fleets: Collective Motion and Sensing Networks in Nature and Robotics*

Naomi Ehrich Leonard
Mechanical and Aerospace Engineering
Princeton University

From bird flocks to fish schools, animals move together and respond to their environment in remarkable ways; their natural collective motion patterns appear well choreographed and their collective survival strategies seem ingenious. Animal group behaviors inspire design for mobile multi-agent robotic systems, where demanding cooperative sensing tasks, such as exploration and sampling in an uncertain and dynamic environment, find their analogue in natural aggregation behaviors, such as foraging and feeding. However, bio-inspiration of this kind is not transparent because the natural “design” mechanisms are not well understood. The joint challenge is to explain the enabling mechanisms in animal groups and to define provable mechanisms for robotic groups. And this suggests an integrated approach: formal bio-inspired models and analysis tools derived to synthesize collective robotic motion and exploration can be used to evaluate design hypotheses for animal groups; subsequent revelations from the biology will in turn inspire new approaches for robotic systems.

I will discuss mobile robot and animal networks using a common mathematical framework that builds on coupled oscillator dynamics and communication graphs. I will describe application to an adaptive ocean sampling network, a successful, recent field experiment in Monterey Bay, CA and an investigation of dynamics and decision-making in fish schools.

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