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Topological and behavioral disorder in collective motion

DAVID QUINT, University of California Merced

A major underlying assumption in many studies on the collective motion of self-propelled agents has been that the environment is continuous, isotropic and ordered and agents are all identical. In the natural world there are many examples of disordered environments or heterogeneous swarms where collective motion can exist. Examples include bats that navigate natural caverns via echolocation, schools of fish that maneuver through dark and light areas, microbial colonies that move about in heterogeneous soil, quorum sensing bacteria, crowds of people that are evacuating a building and traffic flow in major cities. In general disorder can arise from two basic sources that inhibit/augment both movement and information flow, those that represent physical obstacles (i.e topological), (*extrinsic*), and those that arise from behavioral heterogeneties within the swarm itself (*intrinsic*). In either case, extrinsic or intrinsic, disorder can be quenched or dynamic in space or time or both. To understand the effect of the various forms of disorder that can be present in the environment of the agents, we study both discrete and continuous $2d$ agent based models that utilize only local interactions and study the transition to the collectively moving state as a function of the amount of disorder or behavioral heterogeneities present in the environment. I will present our recent results and discuss the effect that disorder has on collective motion and the general physical mechanisms that swarms, either real or artificial, could utilize in order to overcome disorder in their environment.