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A persistent homology approach to collective behavior in insect swarms MICHAEL SINHUBER, NICHOLAS T. OUELLETTE, Civil & Environmental Engineering, Stanford University — Various animals from birds and fish to insects tend to form aggregates, displaying self-organized collective swarming behavior. Due to their frequent occurrence in nature and their implications for engineered, collective systems, these systems have been investigated and modeled thoroughly for decades. Common approaches range from modeling them with coupled differential equations on the individual level up to continuum approaches. We present an alternative, topology-based approach for describing swarming behavior at the macroscale rather than the microscale. We study laboratory swarms of Chironomus riparius, a flying, non-biting midge. To obtain the time-resolved three-dimensional trajectories of individual insects, we use a multi-camera stereoimaging and particle-tracking setup. To investigate the swarming behavior in a topological sense, we employ a persistent homology approach to identify persisting structures and features in the insect swarm that elude a direct, ensemble-averaging approach. We are able to identify features of sub-clusters in the swarm that show behavior distinct from that of the remaining swarm members. The coexistence of sub-swarms with different features resembles some non-biological systems such as active colloids or even thermodynamic systems.

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