Collective behaviour of active systems

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Active matter spans a wide range of time and length scales, from groups of cells and synthetic self-propelled colloids to schools of fish and flocks of birds.
Active matter systems are composed of out-of-equilibrium units that consume energy to move. A characteristic feature of active matter is collective motion leading to nonequilibrium phase transitions or large scale directed motion [1].

One of the simplest yet insightful model to unravel the features of Active Matter is the so-called Active Brownian Particles (ABPs). One paradigmatic phenomenon observed in suspensions of repulsive ABPs is the emergence of Motility Induced Phase Separation (MIPS), characterised by dense regions of slow particles and dilute regions of fast ones [2, 3]. Another relevant model is the so-called Vicsek model [4], perhaps the simplest model displaying a transition to collective motion.

Clearly, the theoretical framework describing active systems has shown tremendous success in finding universal phenomenology.

However, further progress is often burdened by the difficulty of determining the forces controlling the dynamics of individual elements within each system. Accessing this local information is pivotal for the understanding of the physics governing an ensemble of active particles and for the creation of numerical models capable of explaining the observed collective phenomena. For this purpose, we have proposed a machine-learning tool, ActiveNet, that uses the collective movement of particles to learn one and two body forces acting on each particle.[5]

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