Complexity mini-project proposal

Project title: Animal behaviour in quasi one dimensional systems

Supervisor

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Project outline:

There has been an enormous amount of interest in recent years in the collective behaviour of interacting animals. These "swarms" can involve organisms of complexity ranging from bacteria to insects to mammals. A seminal paper by Vicsek *et al.* [1] proposed a simple model for swarming that has been extensively studied in two dimensions. In this model the direction of movement of an organism is effected by the average direction of motion of nearby animals. In addition there is some randomness to their choice. The magnitude of this random "noise" affecting their direction is one of the theory's few tuneable parameters, the other being the range of the interactions, the speed of movement and the number (density) of animals. The Vicsek model, while simple to implement on a computer, is able to reproduce extremely complex and apparently realistic swarming patterns.

Several recent experiments have sought to examine the behaviour of insects on long or circular tracks [2]. The track (perhaps a closed tube) does give the insects some opportunity to move in two dimensions, along or around the tube. However, if the track is much longer than it is wide, and one is interested in patterns of motion that are larger than the tube width, the insects can be thought of moving in what is described as a "quasi" one dimensional system. Simply put one might seek to build a model built on the (average) density and velocity of insects at a distance x along the tube at time t.

Building such a model is the goal of this project. Precise scientific questions can be asked, e.g. concerning the coherence of motion (the time taken for swarm of a given length to reverse direction) and how this varies with the size of the compact dimension (the tube radius). Looking into the future the ultimate goal would be to infer the inter-animal interactions that are most consistent with data and then to use this to ask questions that relate to improving farming practices or controlling pests, such as locusts. These models might be tested in controlled experiments.

The successful student will undertake the following:

1. Literature search and a comparison and criticism of existing approaches to modelling animal behaviour.

2. Construction and analysis of a simple model for the behaviour of "Vicsek" animals in a quasi one-dimensional system. This will involve computer simulation and the comparison of these results with a simple mean field model.

3. A brief discussion of possible approaches for comparison of such a model with experimental data, extracted by video using animal recognition software.

References

[1] Vicsek T, Czirok A, Ben-Jacob E, Cohen I, Shochet O (1995) Novel type of phase transition in a system of self-driven particles. *Phys Rev Lett* **75**, 1226.

[2] J. Buhl, D. J. T. Sumpter, I. D. Couzin, J. J. Hale, E. Despland, E. R. Miller, S. J. Simpson (2006) From Disorder to Order in Marching Locusts. *Science* **312**, 1402.