

Today, I'll first quickly summarise our readings with take home messages from each of them. Following that, I'll proceed to talk about some of the recent developments in the field of collective behaviour.

To begin with, the paper on the Vicsek model speaks about two things

1. The uncanny resemblance between phase transitions of systems in equilibrium vs those which are far from it.
 2. Perhaps more importantly, it was his simple set of interaction rules to model collective behavior which further added to the paper gaining such popularity over the years. *But I wonder why the boid animation paper didn't get an equivalent response given its rules were also quite simple.* Anyway, the Vicsek model does have its limitations...
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The paper on clapping, through experiments, the team showed that the transition from asynchronous to synchronous clapping is accompanied by a period-doubling and a reduction in the dispersion of frequencies of individual clapping

The escape room paper showed a mix of individual exploration and herd behaviour is an optimal solution in the studied emergency situations

What was interesting to me in the mexican wave analysis was the inherent bias towards clockwise travelling waves.

Ballerini's paper on topological vs metric distance challenged the entire notion of how these living systems like bird flocks and fish schools were viewed. Perhaps, in hindsight, it is now easy to convince ourselves that humans too rely on a similar topological interaction rather than metric. It was also interesting to note the difference in robustness to perturbations of the two models.

All this being said, work in collective behavior is still growing. There has been a constant supply of models. As you will see all of these model does match the real world observations to some degree.

There's Ian couzins lab at Max Planck in Konstanz have this 3D model governed by zones of attraction, repulsion and alignment.

Friella's team in France have this model based on hydrodynamic interactions

Romanczuk's team in Berlin has this model based on vision.

Then theres this highly data driven work decoding inter-individual interactions done at Guy's lab in Toulouse

And ofcourse on the application side of things, theres work by Wyss instiute at Harvard in swarm robotics.

To conclude, I'd like to briefly mention a major assumption in collective behaviour simulations and modelling. Any complex systems for that matter.

When trying to model macrosopic behaviour from inter-indivdiual interactions, usually it is based on the assumption of pairwise inter-individual interactions. This is seen in the figure here where

the focal individual in yellow performs some sort of summation of information obtained from looking at each of its neighbours individually.

However, if the same system is modelled using triads of this sort which I call a higher order interaction,

the macropsic behaviour is different as seen in the bifurcation diagram here. I'm sorry for the jargon but you dont have to worry about what bifurcation diagrams are. The take home message can be visually seen via the difference between the two plots. Higher order interactions can give rise to different emergent behaviour when compared to simple pairwise interactions.

Infact a fascination with collective behaviour was probably the start of my journey towards this CNS program :P