Modelling mixed-species flocking

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Introduction to Project:

The field of collective motion was conceived by the seminal work of Vicsek et.al. in 1990s [1] drawing our attention to a long neglected phenomena occurring everyday in front of our eyes and explaining it with a very simple model of metric interaction [2].

Mixed species flocks abound in nature especially in northern temperate zones and tropical forests. It is believed that mixed species flocks provide greater predator defence due to dilution effect, many-eyes effect and increased vigilance. They also provide foraging benefits through greater resource finding ability. In their work on mixed-species flocks, Sridhar et al [3] report that across the world, for all species forming mixed flocks, foraging rates increase and vigilance decreases in mixed species flocks as compared to solitary individuals as well as single - species flocks. They also report that the benefits are not necessarily enjoyed to the same extent by both species - often the follower species benefits more. These findings make make mixed species flocks interesting to look at from a animal behaviour point of view as to why the less benefited species would participate in mixed flocks in the first place.
We however, focus on the structure and dynamics of mixed flocks. The aim of the project is to look at mixed species flocks through the lens of the Vicsek Model We aim to study the the dynamics and emergent structures in mixed flocks using the framework of Vicsek model. We try to address a few fundamental questions:

- Develop a mixed species model where inter-species and intra-specices flocking interactions are not identical.
- How does the difference in interspecies and intra-species interactions affect the phase transition? More specifically, how does the critical noise value (η_c) as a function of the difference in the above parameter.
- Structure: Is there a natural level of spatial segregation within the flock? We try to quantify the extent of segregation of species within

the flock as a function of the difference in interspecies and intra-species interactions.We aim to do so by looking at the group size distribution of the two species.

- Information: We measure the extent and rate of information transfer in the flocking, looking at the difference in transfer within each species against that between the species.

- We would also want to look at if mixed species flock can emerge from encounter of two completely ordered single species flocks despite the tendency to favour your own species(since $r_{AA} = r_{BB} > r_{AB} = r_{BA}$). For example we can try to look at mixing of two anti-parallel ordered flows of species A and B and whether we obtain a mixed AB flock due to the mixing or not.

Model Details

We consider equal number of individuals of two similar species. The individuals interact in the manner proposed in the standard Vicsek Model, except that while the interaction radius for individuals of same species is r, interaction radius for individuals of other species is $r - \Delta r$, where $\Delta r \in [0, r]$. In the $\Delta r \to r$ limit we recover our original Vicsek Model for two non-interacting species, on the opposite limit of $\Delta r \to 0$ we obtain essentially a single species Vicsek model.

References

1. T.Vicsek et.al, *Novel type of phase transition in a system of selfdriven particles*, **Phys.Rev.Lett. 75,1226-1229** (1995)
2. T.Vicsek and A.Zafeiris,*Collective motion*, **Phys.Rep. 517, 71–140**, (2012)
3. Sridhar, Hari and Beauchamp, Guy and Shanker, Kartik, *Why do birds participate in mixed-species foraging flocks? A large-scale synthesis*, **Animal Behaviour 78,2 337-347**, (2009)