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DEPARTMENT OF MATHEMATICS
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Modeling Complex Systems (1MA256)
Spring 2023

LAB 4: Self-propelled particles

The deadline for this assignment is May 26th.

Please submit by email, upload to GitHub or any other "box", if the files/data are too large (provide a link). All code should be included. Feel free to submit videos illustrating your results where appropriate, by email or uploaded elsewhere such as vimeo or youtube. You may work in groups of size 1-7, and only one group member needs to submit the assignment. State clearly the members of the group.

Task 1: Write a code which implement the boids models. Choose three radii $r_1 < r_2 < r_3$, assume that each particle has a unit mass and a unit speed (but varying velocities).

1) A particle gets repelled away from the common center of mass of particles in zone 1. That is it's new velocity is aligned along the vector from the particle to the center of mass, and away from the center of mass. This gives you angle θ^1.

2) A particle aligns its velocity with the mean velocity angle of particles in zone 2. This produces angle θ^2. In this zone, you can implement Vicsek polarization model insted of the mean velocity.

3) A particle gets attracted to the center of mass of all particles in zone 3. That is it's new velocity is aligned along the vector from the particle to the center of mass, and towards the center of mass. This gives angle θ^3.

4) Now, update the velocity of the particle by including all effects with weights:

$$\theta_j(t+1) = \rho_1\theta^1(t) + \rho_2\theta^2(t) + \rho_3\theta^3(t) + \rho_4 e, \quad \rho_1 + \rho_2 + \rho_3 + \rho_4 = 1,$$

where e is picked up randomly from some interval $[-\eta, \eta]$ $\eta < \pi$.

5) Make a movie of a boids moving flock.

Task 2: Develop a measure of aggregation for the model. The aggregation measure should capture how close together group members are. You can implement the aggregation measure in any way you like, as long as it makes sense. Explain why you chose that form.

There are 8 parameters in the model. Make plots of how the parameter values in your model affect your aggregation measure (such as the 2D plot of the measure vs $x = r_1/r_3$ and $y = r_2/r_3$ in the region $0 < x < y < 1$, and 1D plots of the measure vs ρ_i). Are there any phase transitions - jumps in the aggregation measure?