

Data Science Course

Understanding swarm behaviour

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Presentation Overview

- All models: `sim300.py`
- Paper 1: Effective leadership and decision-making in animal groups on the move (Couzin et al)
- Paper 2: Double milling in self-probelled swarms from kinetic theory (Carrillo et al)
- Quantification

All models: `sim300.py`

Models available:

```
'Simple speed coupling.....smpl'  
'Couzin model.....czn'  
'Viscek model.....vsck'  
'Couzin-2 model.....czn2'  
'Mill model.....mill'
```

Paper 1: Effective leadership and decision-making in animal groups on the move (Couzin et al): czn2

same as Couzin 1 model but without orientation phase

Paper 2: Double milling in self-propelled swarms from kinetic theory (Carrillo et al): mill

A kinetic theory based approach for swarming systems of self-propelled discrete particles.

Individuals driven by self-propelling forces and pairwise attractive and repulsive interactions lead to various morphologies, e.f. flocks, rotating mills, rings and clumps.

We can

- average in direction or velocity
- consider different zones of interaction and averaging (see Couzin et al)

Paper 2: Double milling in self-propelled swarms from kinetic theory (Carrillo et al): mill

But: As N =particles grows, it becomes increasingly difficult to follow the dynamics of each individual agent. Therefore, we choose a continuous approach where particles are represented by a density field.

Consider N interacting, self-propelled particles governed by the following equations of motion

$$\begin{aligned}\dot{x}_i &= v_i \\ \dot{v}_i &= (\alpha - \beta |v_i|^2) v_i - \nabla_{x_i} \sum_{j \neq i} U(|x_i - x_j|)\end{aligned}\tag{1}$$

where U is a pairwise interaction potential and $\alpha, \beta > 0$ are values for propulsion and friction forces.

Paper 2: Double milling in self-probelled swarms from kinetic theory (Carrillo et al): mill

For U we choose the Morse potential which is a common choice for interacting swarming systems

$$U(r) = \underbrace{-C_a e^{-r/l_a}}_{\text{attraction}} + \underbrace{C_r e^{-r/l_r}}_{\text{repulsion}} \quad (2)$$

where C_a , C_r denote attractive and repulsive strengths and l_a , l_r their respective length scales.

Quantification