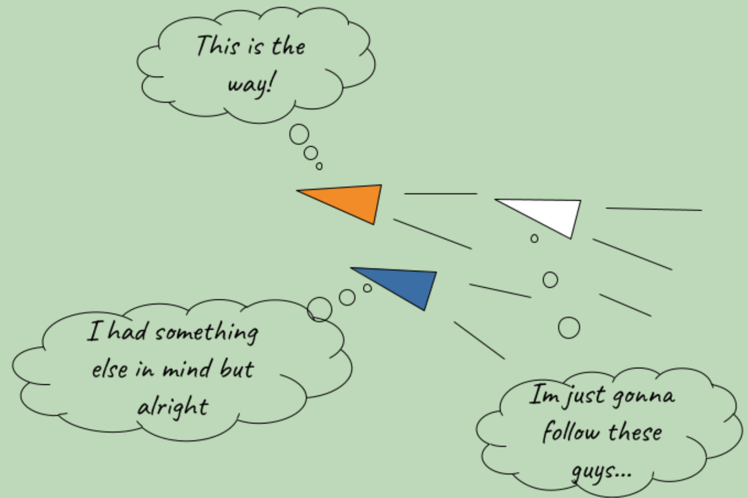
Decision making in collective motion



Viggo Segersten

Supervised by John Tember

Iain D. Couzin, Jens Krause, Nigel R. Franks, and Simon A. Levin. Effective leadership and decision-making in animal groups on the move. Nature, 433(7025):513–516, 2005.

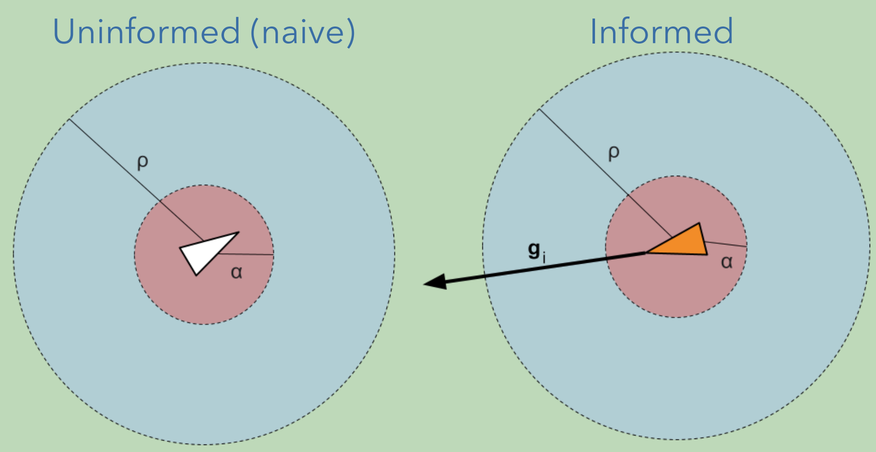
Motivation

By studying **information transfer** and how groups reach common decisions in **agent based models**, one can gain insight into biological systems, such as fish and bird groups, as well as general principles of self-organizing systems. This knowledge is important for interpreting animal behavior in nature but can also inspire technical applications, for example in robotics, and swarm intelligence.

The model used is inspired by Couzin et al. (2005) . There are two main questions being investigated:

- How does the proportion of informed agents required to successfully guide the group change with the size of the group?
- Does the proposed feedback mechanism facilitate **consensus decisions** when there exists different individual preferences?

The Couzin model



Nr. 1 priority: Agents want to keep a minimum distance α to its neighbors: $\mathbf{d}_i = -\sum_{j\neq i} \hat{\mathbf{r}}_{ij}$

If no agent too close: Agents want to orient and attract themselves towards neighbors within distance ρ :

$$\mathbf{d}_i(t+\Delta t) = \sum_{j\neq i} \hat{\mathbf{r}}_{ij} + \sum_{j} \hat{\mathbf{v}}_j$$

Informed agents also have a preferred direction $\mathbf{g}$. This preference is weighted using ω ranging from 0 to 1.

$$\mathbf{d}'_i(t+\Delta t) = \hat{\mathbf{d}}_i(t+\Delta t) + \omega\hat{\mathbf{g}}$$

Feedback mechanism: Whenever an informed agent finds itself aligned with its preferred direction, its $\boldsymbol{\omega}$ is **increased**, otherwise it is **decreased**.

Results

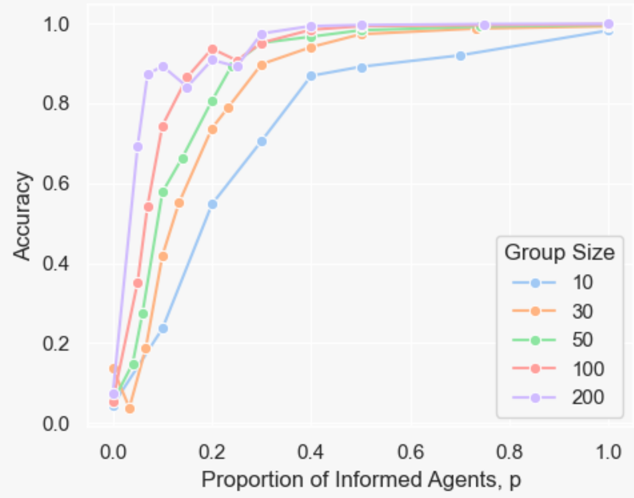


Fig 1. The simulations show that the proportion of informed agents needed to achieve high accuracy is lower for larger groups.

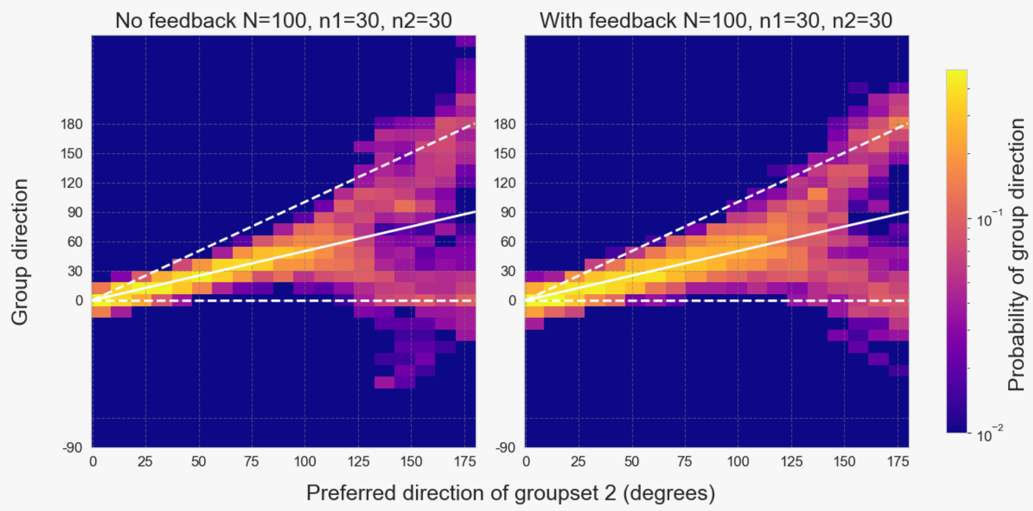


Fig 2. Two different preferred directions among the informed agents: Although not too distinct one can spot a difference in the final group directions when the feedback mechanism is applied. With feedback, final directions for the larger conflict angles (150-180 degrees) align slightly better with the preferred directions (dashed lines).

Conclusions / Implications

Results from Figure 1 confirm that information can be effectively transmitted through a group using only local interactions, without explicit leadership signals. This suggests that collective motion in animal groups does not require individuals to identify or follow specific leaders. The proportion of informed individuals needed to achieve high directional accuracy decreases with increasing group size, indicating that only a small informed minority may be sufficient in large groups. This implies that natural systems may balance the benefits of informed individuals against associated costs, leading to an evolutionary efficient number of leaders. Despite its simplicity, the feedback mechanism in the model facilitates collective decision-making and effective information transfer.