Dynamics of flocking in presence of noise

Harishankar M. and Vishnu R. Unni *

From a school of fish to a flock of birds, seemingly synchronized movement of animals in the biological world has always been a fascination to humans. Such collective motion is the result of interaction among multiple agents and is characterized by complex behaviors such as emergence, adaptation, and self-organization. Past studies have focused both on characterizing and simulating the collective motion observed in nature. The phenomena of collective motion is not only relevant in describing the multi agent behavior in the natural world. The real-world engineering applications of flocking of agents are numerous ranging from swarm robotics to novel computation methods.

Systems undergoing collective motion can be described by a complex multi-agent model which can be numerically simulated using an agent-based approach. Numerous such models have been proposed, of which, a popular one is the Reynold's Boid model [1]. Generally, most collective interaction models for flocking follow a simple agent-based approach where agents interacts following simple rules leading to the rise of emergent collective behavior.

Any physical system, when modeled, has to take into account external perturbations as well as environmental noise. In general, noise is viewed as an undesired element. Ref. [2] and [3], examine how different noise levels can affect the overall stability of different models for flocking. However, the effect of noise on the transient dynamics resulting in flocking such as the time taken to form a flock, formation of local clusters en route to flocking, etc. are not well understood.

In this paper, we will be using a model similar to that used in Jia and Vicsek [3]. The model follows all the basic rules of Boid's model. The model was validated for no noise condition. It was observed that the agents are able to flock together. Each agent in the model looks into three aspects for updating its instantaneous velocity. First, it will have a component of velocity which tries to align itself with the agents within a neighborhood, secondly, it will have a repulsion component that tries to move away from agents if they get too close to avoid a collision. Finally, there will be a component that attracts the agent toward the center of the flock to maintain the cohesiveness of the flock. A flocking coefficient, f, is defined to measure the efficiency of flocking as follows:

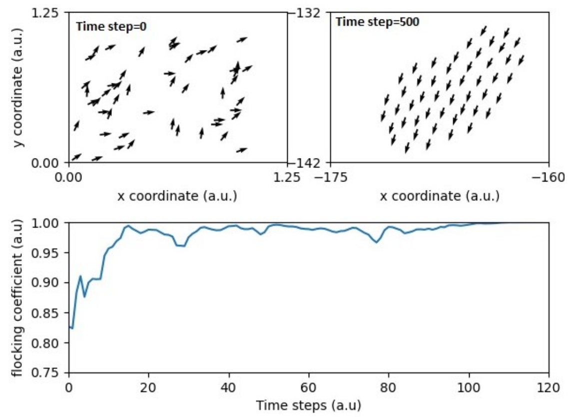

Figure 1: Flocking in the absence of noise

$$f = \frac{1}{N} \sum_{i=1}^{N} \frac{\vec{V_i}}{|\vec{V_i}|} \tag{1}$$

Here, N refers to the total number of particles involved. Figure 1 shows the initial and final position (after 500 time instants) of 50 agents whose initial distribution of position and velocity is random in the two-dimensional space.Fig. 1 also shows the graph of the flocking coefficient parameter vs. time in the absence of noise. Gaussian noise is added to the agent's velocity and the effect is studied. In the poster, we will show the effect of noise on the dynamics of flocking. We will also show that in presence of noise flocking happens through nucleation and growth and that under certain condition, noise improves the flocking time.

References

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*Harishankar M is a undergraduate student at IIT Hyderabad, email: ee21btech11022@iith.ac.in. Vishnu R Unni is an Asst.Professor in Mechanical and Aerospace Department at IIT Hyderabad, email: vishnu.runni@mae.iith.ac.in