Contribution ID : **13** Type : **Talk**

Learning to flock with reinforcement learning.

In many biological systems the individual agents cluster together in space and exhibit collective behavior [1]. Thousands of starling birds show spectacular collective aerial maneuvers near their home, migratory birds migrate as a flock, school of fish forage together, thousands of insects march and feast on the crop fields etc are few examples[2-4].
Many simulation models are proposed to understand the fundamentals principles governing the collective behavior in such systems [5-7]. Yet such rules are not well understood.
We study multi-agent systems with machine learning techniques to understand the optimal decision making process by the agents to exhibit collective behavior. One of the widely used machine learning technique, that we implemented, is called the reinforcement learning[8]. The broad scheme of the reinforcement learning technique can be summarized as following. Agent as a decision maker takes action in its environment which is in state (s) and environment provides a reward signal and new state of the environment (s') to the agents as a consequence of the action performed by the agent. The goal of the agent is to discover a policy (by try and error) that maximize the total reward. A policy is a map from states to actions that dictates the best action (a*) to perform in the state (s).
We implement reinforcement learning technique to understand the decision making process by the individual agents in order to form a flock. For that purpose, we set reward scheme that encourage congregation of the agents. We observe that agents with learning algorithm discover multiple policies to maximize the total reward for congregation. While following these policies agents not only congregate but also form highly polar ordered states as observed in real flocks[5]. In highly polar ordered states, all the agents move in the same heading direction. And one of the policies that agents discovered is equivalent to the well known statistical physics model called the Vicsek model[6].

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Session Classification : Session 4