Multi Agent Systems

An Introduction

Rezwan Khan

February 3, 2022

Outline

Flocking and Swarming

- Collective Animal Behavior.
  - Birds
  - Fish
  - Bacteria
  - Insects

Figure: Swarming

Figure: Flocking

Boids, 1986

- Craig Reynolds.
  - Computer Graphics and Artifical Life Expert.
  - Published the paper in 1987 ACM SIGGRAPH. [1]
- bird-oid object or, Boids

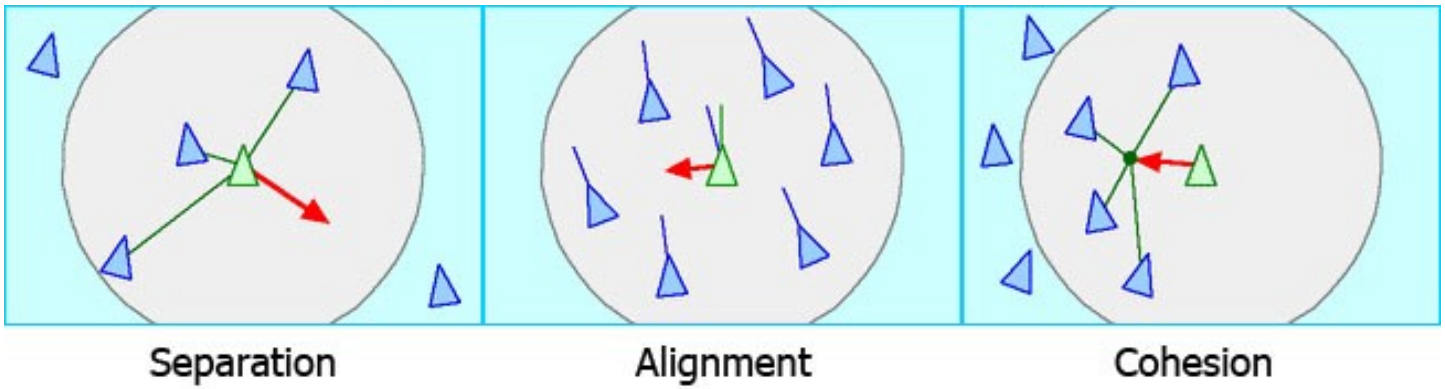

Figure: Rules Applied for Boid

- Stanley and Stella in: Breaking the Ice (1987)
- Batman Returns (1992)

Phase Agents

- Tamás Vicsek.
  - Published a paper describing behavior of particles(1995).[2]
  - Started a whole new research area.
  - I will explore this model for today's discussion.

Vicsek Model

- Particles/ Agents has two properties:
  - Heading/Direction
  - Velocity/Speed
- All the agent has same absolute speed.
- Direction is updated according to a simple rule.

Vicsek Model (contd.)

- Particles are in square shaped cell size L with periodic boundary.
- Interaction radius $r = 1$
- Time unit $\Delta t = 1$

Vicsek Model (contd.)

- Notations
  - $x_i(t)$ is the position.
  - $\theta_i(t)$ is the heading.
  - $v_i(t)$ is the velocity. Velocity is kept constant or absolute value v for the model.
- at each time interval $\Delta t = 1$ the particle/agent updates position and heading using following rule:
  - $x_i(t+1) = x_i(t) + v_i(t)\Delta t$
  - $\theta_i(t+1) = \langle \theta_i(t) \rangle_r + \Delta\theta$
- where, $\langle \theta_i(t) \rangle_r = arctan \left[\frac{\langle \sin(\theta(t)) \rangle_r}{\langle \cos(\theta(t)) \rangle_r} \right]$
- and, $\Delta\theta$ is random number from uniform interval $\left[-\frac{\eta}{2}, \frac{\eta}{2} \right]$

Let's Simulate

- Case 1 : $L = 7$, $\eta = 2.00$, $Agents = 300$
- Case 2 : $L = 25$, $\eta = 0.1$, $Agents = 300$
- Case 3 : $L = 5$, $\eta = 0.1$, $Agents = 300$
- Written in Python3 using MESA framework.
- I will upload the code in github and will share the link.

Multi Agent Behavior

- Consensus
- Formation
- Clustering

Some Thoughts

- What happened next?
- Applications.
- AI?
- Control Theory.

Skills needed for research

- Modeling.
- Graph Theory.
- Non-Linear Control.
- Embedded Systems.
- Programming.
- LaTeX

Thank You!


Craig W. Reynolds.
Flocks, herds and schools: A distributed behavioral model.
In *Proceedings of the 14th Annual Conference on Computer Graphics and Interactive Techniques*, SIGGRAPH '87, page 25–34, New York, NY, USA, 1987. Association for Computing Machinery.


Tamás Vicsek, András Czirók, Eshel Ben-Jacob, Inon Cohen, and Ofer Shochet.
Novel type of phase transition in a system of self-driven particles.
Phys. Rev. Lett., 75(6):1226–1229, August 1995.