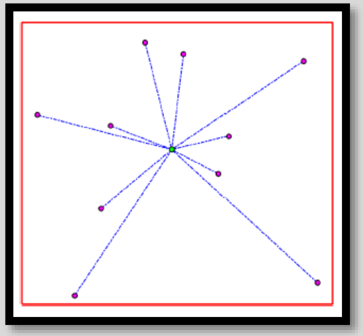
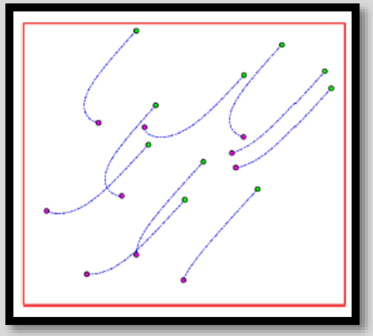
Control of Multiple Robots

- *Problem:* **Coordinating multiple distributed behaviors across a network with more than one decision maker.**
- *Simplification:* **Making teams of robots assemble desired geometric formations.**
- *Solution:* **Formation Control**
  - Reaching Decentralized Agreement
  - Weighted Protocols



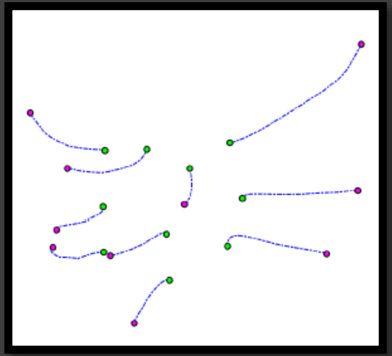


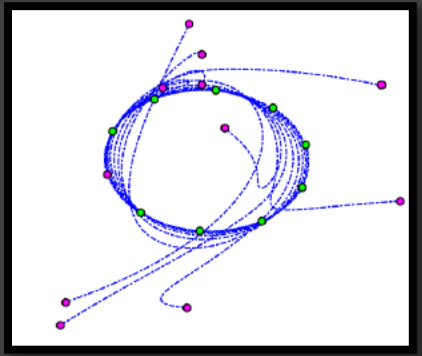
- Algorithms Local
  - Robots Actions – Measurable Information
- Rendezvous Problem
  - A prior agreed upon meeting location.
  - Evaluate total error.
- $\dot{x_i} = -\sum_{(j,i)\epsilon E}(x_i - x_j)$
  - Node Level Dynamics
  - Linear
  - Relative Position Difference between Adjacent Robots
- Node-Level Dynamics
  - $\dot{x} = -Lx$
    - where, L is a varying $N \times N$ dimensional matrix.
    - Consensus Equation
  - Reaching an agreed point.
  - Otherwise, common heading.
  - Information Exchange Network
  - Measurable & Scalable
- Rendezvous Design means Collisions.

Formation Control

Reaching Decentralized Agreement

- Rendezvous Problem
  - Producing Robot Motions
  - Evolution of Network Structure
- Cyclic Pursuit Control & Formation Control
- Robot's must remain Distant





Weighted Protocols

- Symmetric, Pairwise Performance Cost between Robots
- 'Fish' Analogy

$$w_{ij} = \frac{1}{\|x_i - x_j\|}$$

- *Formation Control Protocol*
- *Connectivity Maintenance*
- Rich & Diverse Multi-Robot Response – Assembling a Shape
- Modifications for Spread Arrangement or Covering of an Area.
- Formation Control

$$w_{ij} = \frac{1 - \dfrac{\delta}{\|x_i - x_j\|}}{\left(\Delta - \|x_i - x_j\|\right)^3}$$

Applications

- Factory Floor
- Emergency Response and Rescue
- Homecare
- Natural Resource Monitoring