On Steering Swarms

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1. Abstract

Agents properties:

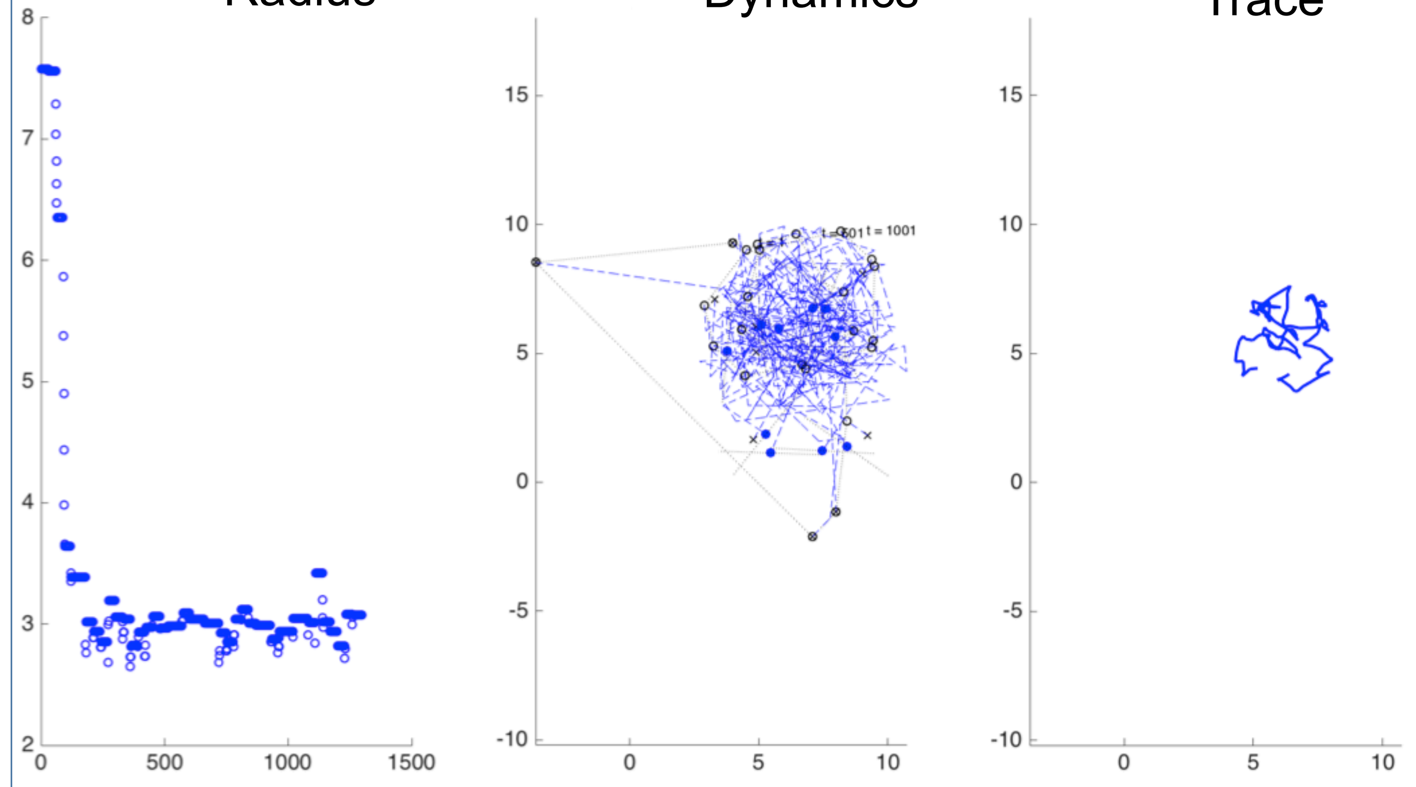
- **Identical** and Indistinguishable
- **Oblivious** (no memory)
- Have **limited visibility**
- **No explicit communication**
- **No common frame of reference** (GPS, compass)

Incentive:

Steering the system via simple global broadcast signals.

2. Gathering Swarms

Enclosing Circle Radius | Agents Dynamics | Centroid Trace



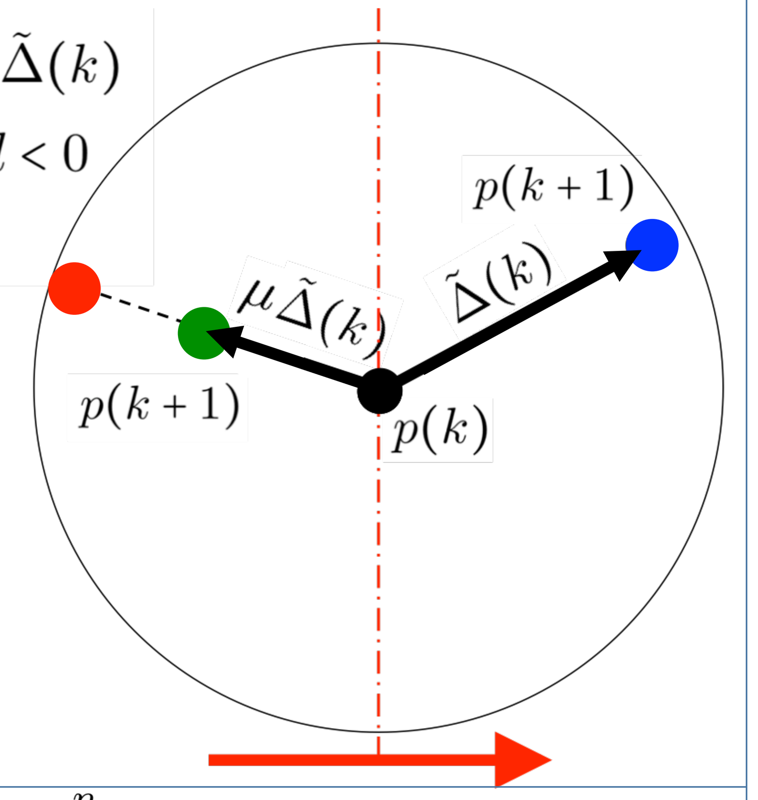
(a) (b) (c)

3. Steering Swarms

Single

$$p(k+1) = p(k) + c(k)\tilde{\Delta}(k)$$

$$c(k) = \begin{cases} \mu & \tilde{\Delta}(k)^T d < 0 \\ 1 & o.w. \end{cases}$$



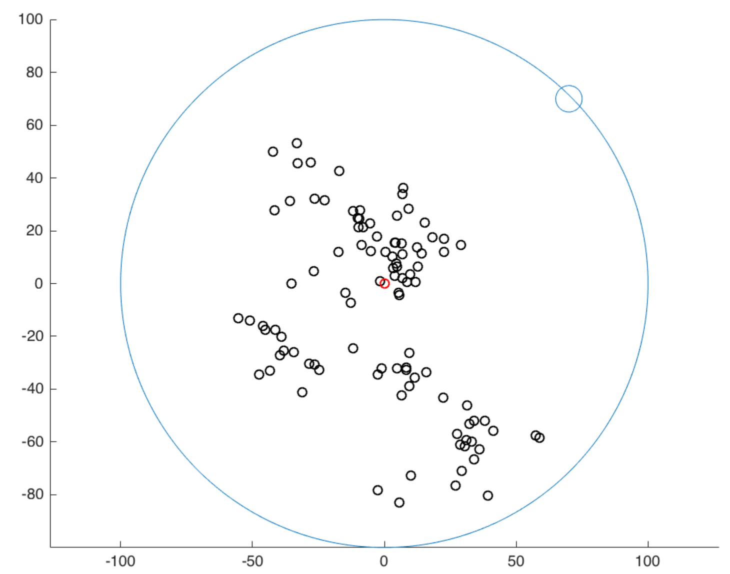
Multi

$$p_i(k+1) = p_i(k) + c(k)[-\sigma \sum_{j=1}^{n}(p_i(k) - p_j(k)) + \tilde{\Delta}_i(k)]$$

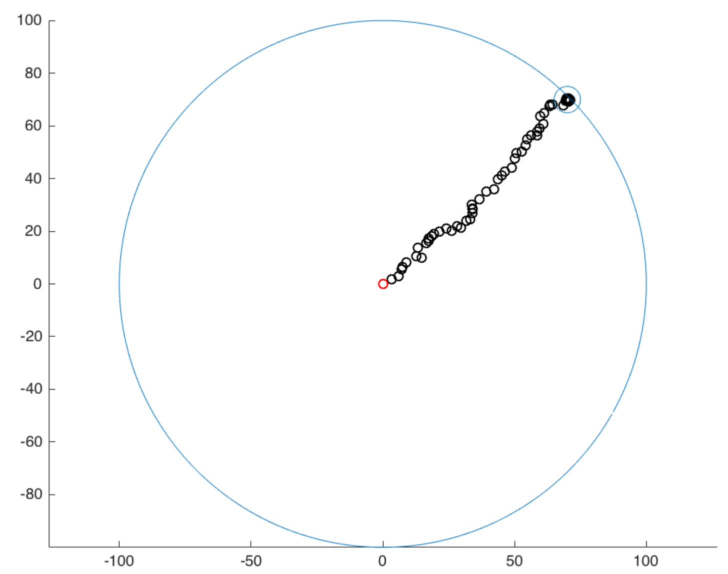
$$c(k) = \begin{cases} \mu & \tilde{\Delta}_{cm}(k)^T d < 0 \\ 1 & o.w. \end{cases}$$

4. Single Agent Simulation

Single agent, randomly jumps in a unit circle, with and without steering mechanism:



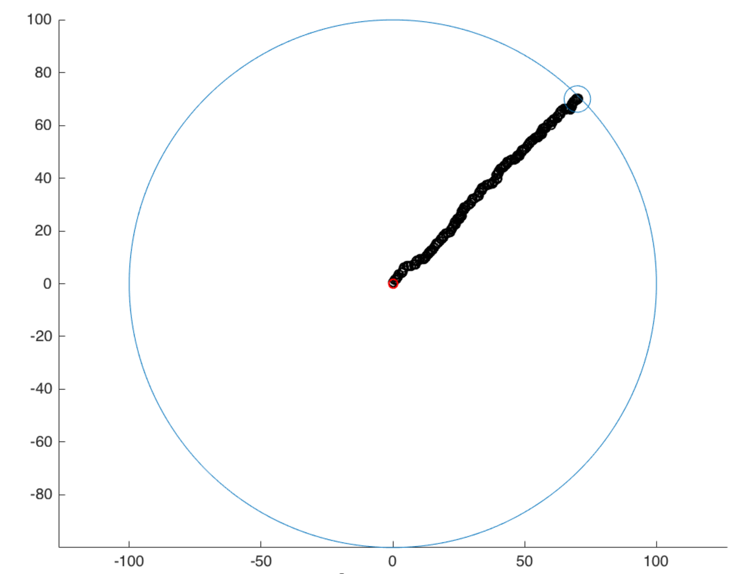
Single agent, random jumps in unit circle.



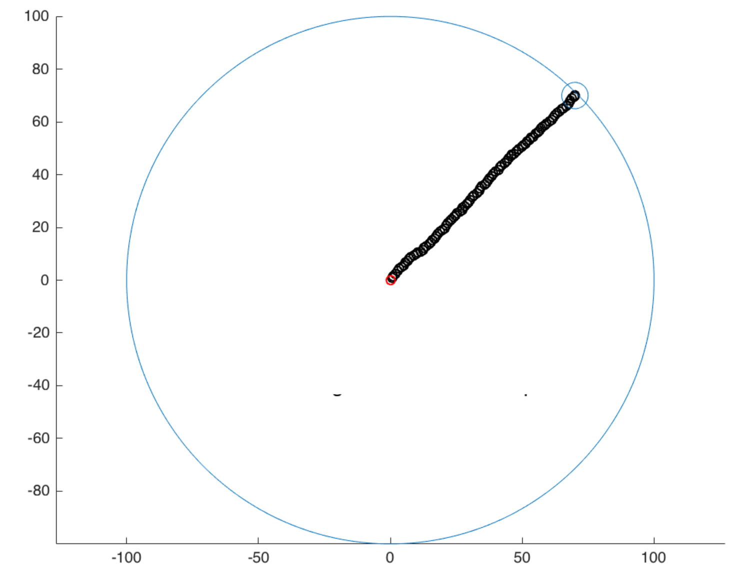
Steering single agent simulation. average number of time steps to reach the target area at distance 100 units: **452**.

5. Multi Agent Simulation

Systems of 10 agents, target point at a distance 100 units, and μ=0.01:



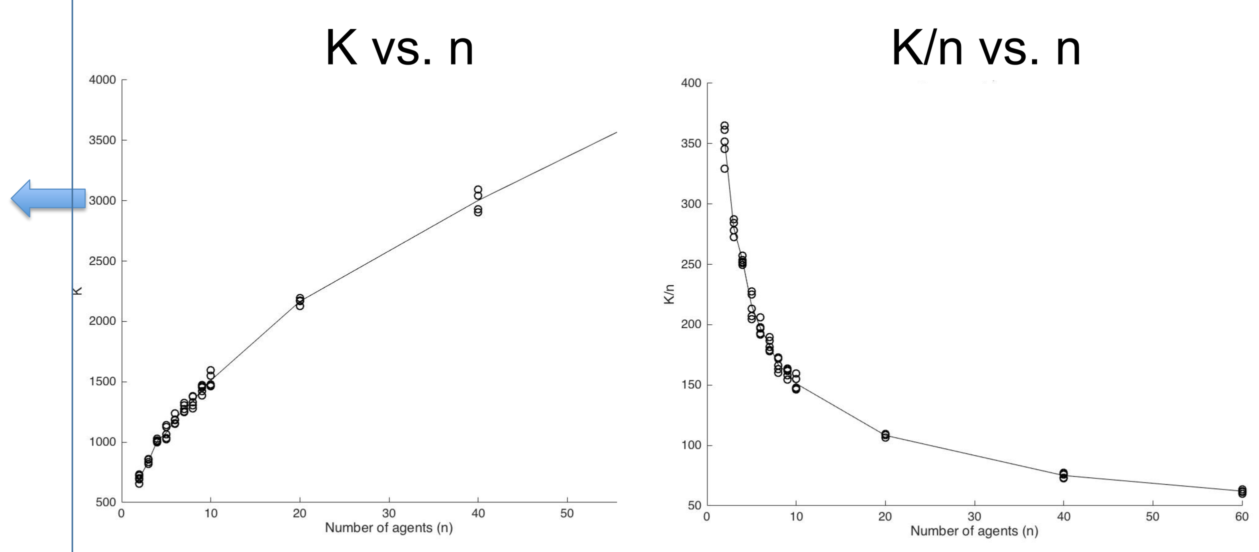
Infinite visibility and full/Bearing-only sensing. average number of time steps to reach the target point area: **1,500**.

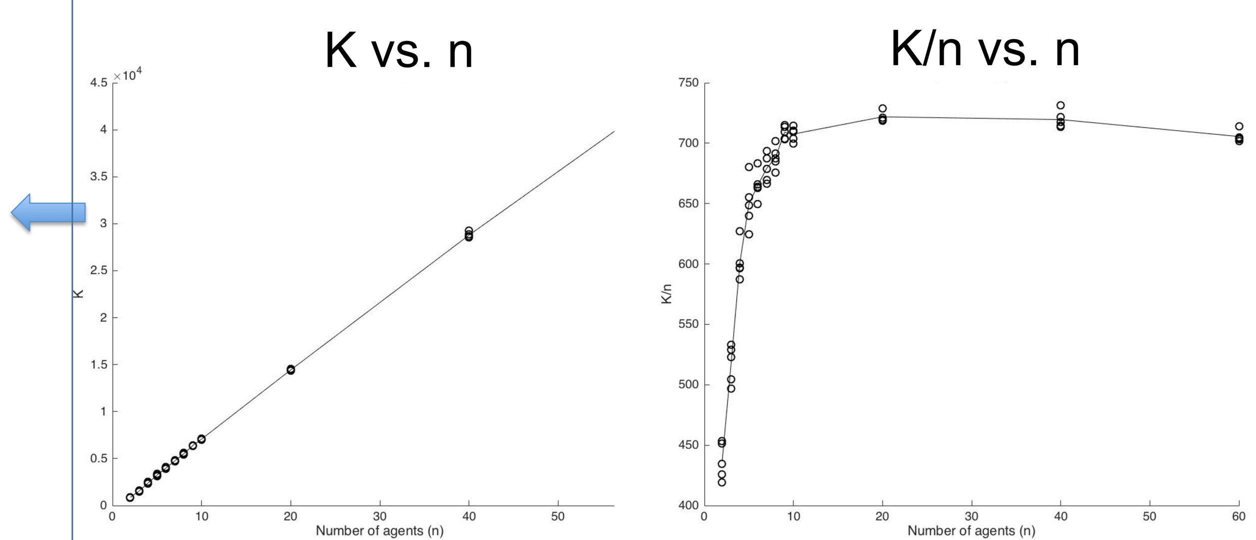


Finite visibility and Bearing-only sensing. average number of time steps to reach the target point area: **8,590**.

6. Simulation Analysis

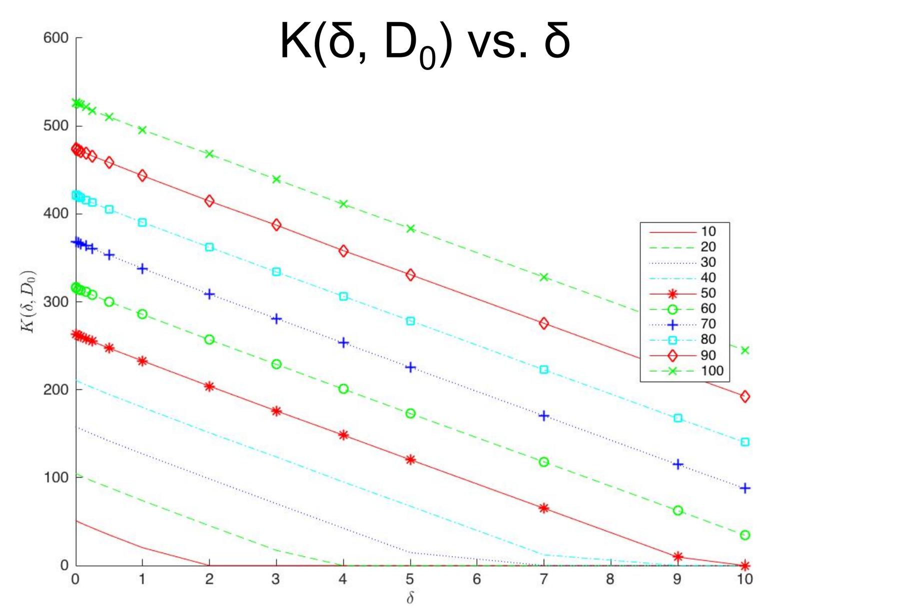
Number of time steps (K) to reach the target area vs. number of agents (n), and K/n vs. n.



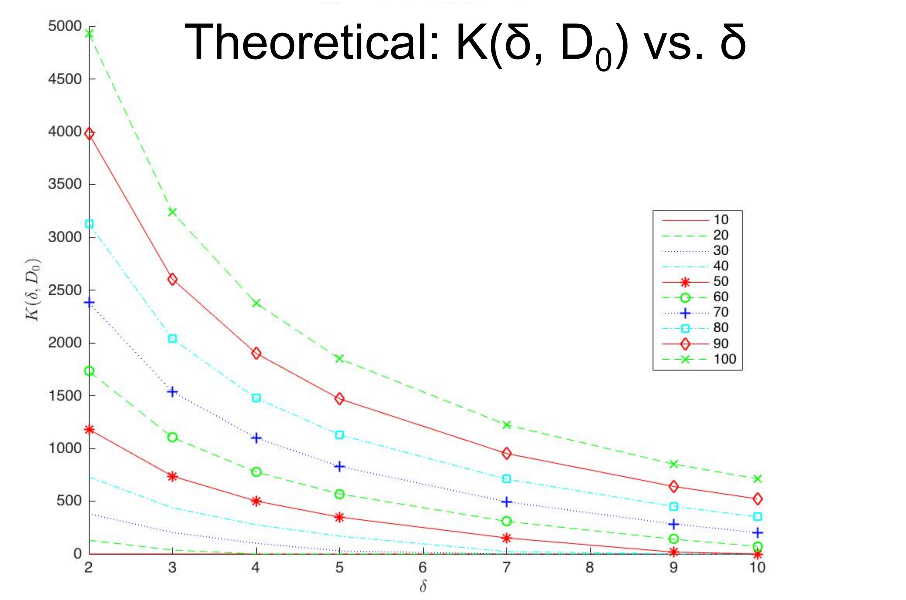


6. Theory vs. Simulation

Theoretic vs. simulated results, single agent evenly distributed random jump to a unit circle.



Plot of K vs. δ by simulation, for different initial D(0) values from 10 to 100.



Plot of K vs. δ by Equation for different initial D(0) values from 10 to 100.