Notes for Autonomous Robots

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1 Introduction

- Starling mermeration $\rightarrow$ an example of a network of autonomous systems
- Sardines

This inspires the following questions.

- Who is the leader?
- Are there multiple leaders
- Is there a leader at all?
- How do they communicate
- Who communicates to whom
- Do they use sensors
- How much of their time is spent concentrating on how to move.

These animals are able to

- Deploy over a given region
- Assume a specified pattern
- Rendezvous at a common point
- Jointly initiate motion/change direction in a synchronized way.

Each individual

- Senses its immediate environment
- Communicates with the others.
- Processes information gathered
- Takes local action

2 Modelling Physical Motion

- Linear Motion – a single integrator
- The Norm is the Length
- Linear motion – a double integrator
- $x \in \mathbb{R}^4, u \in \mathbb{R}^2$ where x is both position and velocity.

$$\dot{x} =$$

- Nonlinear models
- Unicycle

$$x \in \mathbb{R}^3, u \in \mathbb{R}^2$$

$$x = \begin{bmatrix} x \\ y \\ \theta \end{bmatrix}, u = \begin{bmatrix} v \\ u \end{bmatrix}$$

Where v is linear speed and u is angular speed.

- Dubins Vehicle

$$\dot{x} = \begin{bmatrix} v\cos\theta \\ v\sin\theta \\ u \end{bmatrix}$$

Where v is constant and u is bounded.

- Differential drive robot.
- A wheeled mobile robot - a lot like the turtle in turtle graphics.
- The Dirty Derivative

$$f'(x) = \lim_{h\to 0}\frac{f(x+h)-f(x)}{h}$$

Which we can approximate to low fidelity. Now, for major work we'd need better methods.

- Retuning to Dubins

$$\dot{x} = \begin{bmatrix} v\cos\theta \\ v\sin\theta \\ u \end{bmatrix}$$

$$x(t+h) = x(t) + h\begin{bmatrix} v\cos\theta \\ v\sin\theta \\ u \end{bmatrix}$$

Reynolds Flocking and Boids Rules

A basic algorithm for flocking. This has 3 components.

1. Separation to avoid crowding of local flockmates
2. Alignment to move towards the average heading of local flockmates
3. Cohesion steering toward the average position of local flockmates.