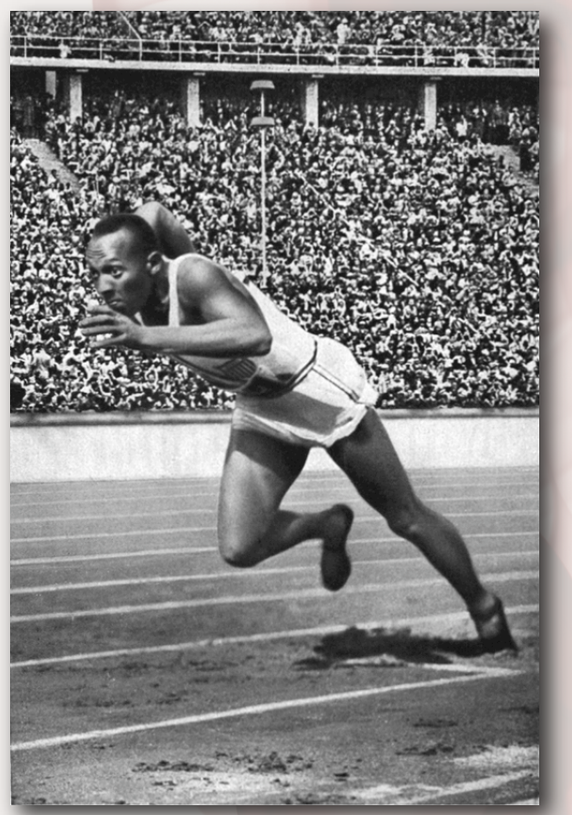
Crowds and Flocks

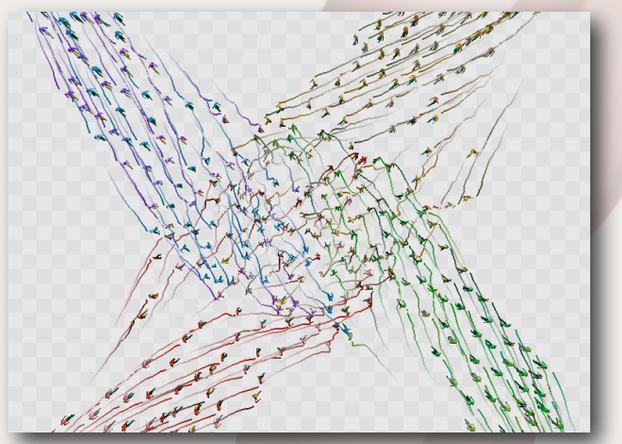
Adrien Treuille

What this is about...

- not human / animal motion.



- ...but group motion paths.



Overview

- Flocking
- Crowds
- Applications
- Current Challenges
- Question

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Honda Video

Source: http://massivesoftware.com/

Real Flocking and Schooling

- **No upper bound on size:**
  - **17 mile schools of Herring with millions of fish.**
  - **=> Localized reasoning.**
- **Collision Avoiance**
- **Centering**
  - **Protection from predators.**
  - **Social Advantages**
  - **Better search.**

Boid Model - I

- **Craig Reynolds 1987**

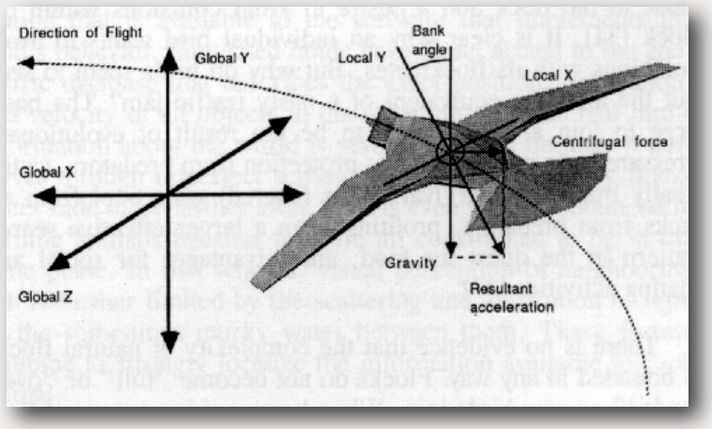
- **Simple local rules lead to compelling flocking behavior.**

Boid Model - II

- **Boid Particle:**

$$\frac{d}{dt}\begin{bmatrix} x \\ \dot{x} \end{bmatrix} = \begin{bmatrix} \dot{x} \\ f \end{bmatrix}$$

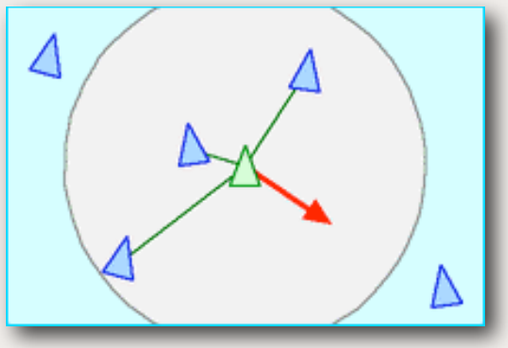
- **Forces:**
  - **Dynamical forces:**



  - **Ordered set of "flocking forces"**

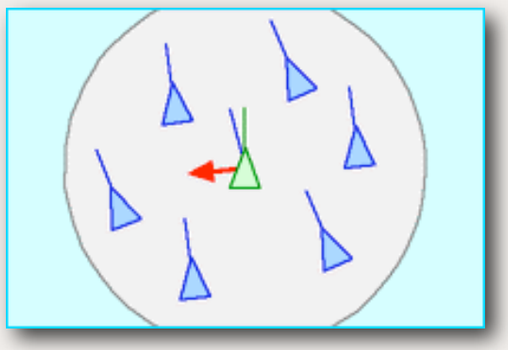
Source: Reynolds. 1987

Boid Model - III



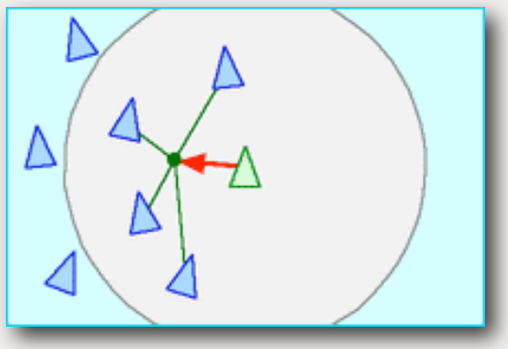
Separation

Steer to avoid crowding local flockmates



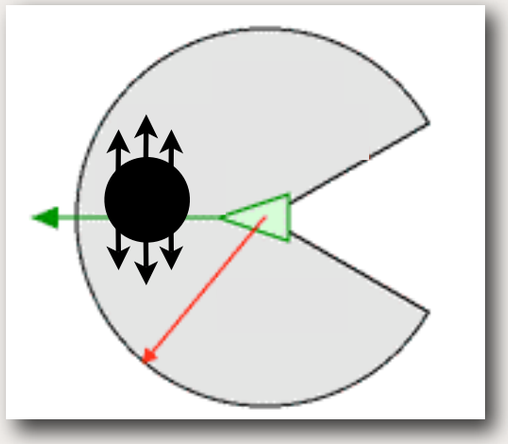
Alignment

Steer towards the average heading of local flockmates



Cohesion

Steer to move toward the average position of local flockmates

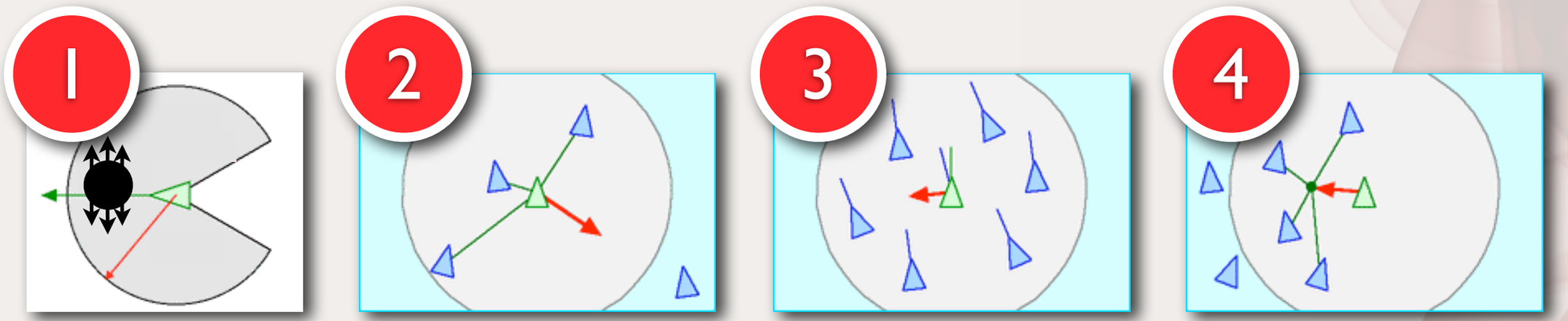


Obstacle Avoidance

Move towads the gradient of obstacles.

Boid Model - IV

- How to combine forces?



- Force ordering scheme.

Making of Honda Video

Source: http://massivesoftware.com/

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Crowds

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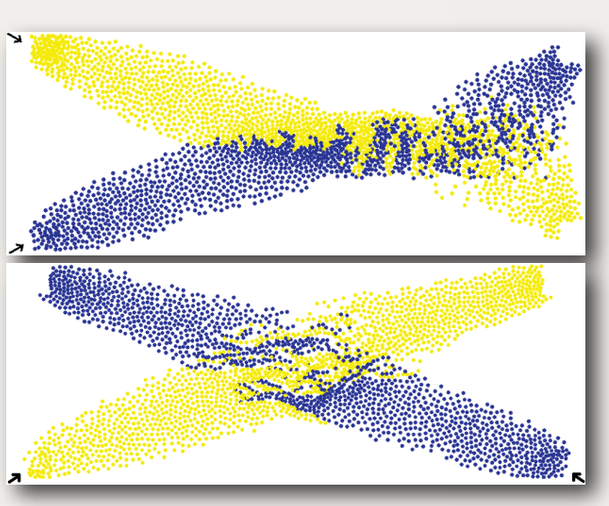
Properties of Real Crowds

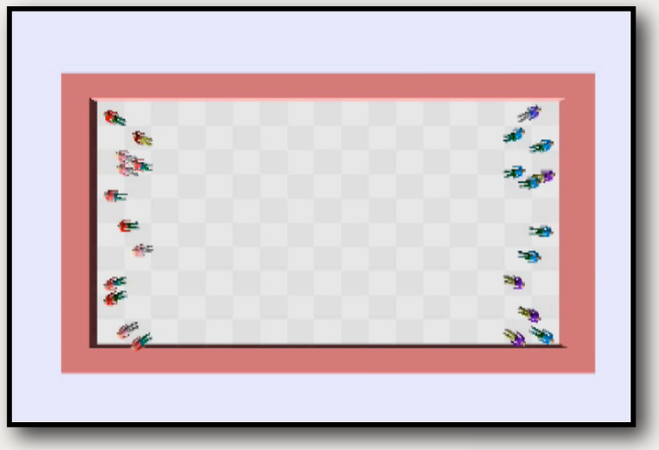
- Goal Directed
- Obstacle / Collision Avoidance

- Striping



Source: Helbing et. al. 2005

- Lane Formation

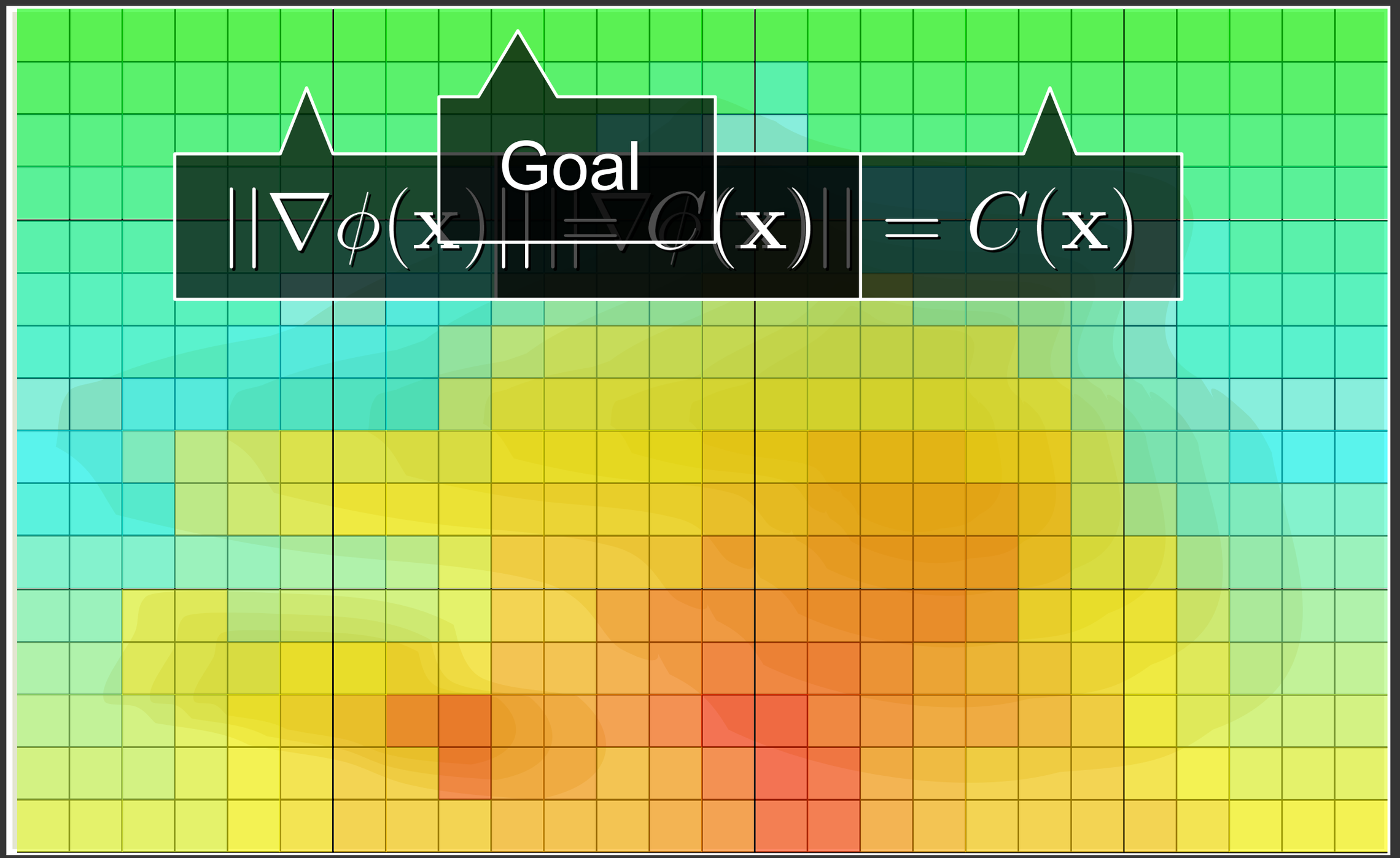


Steering Forces

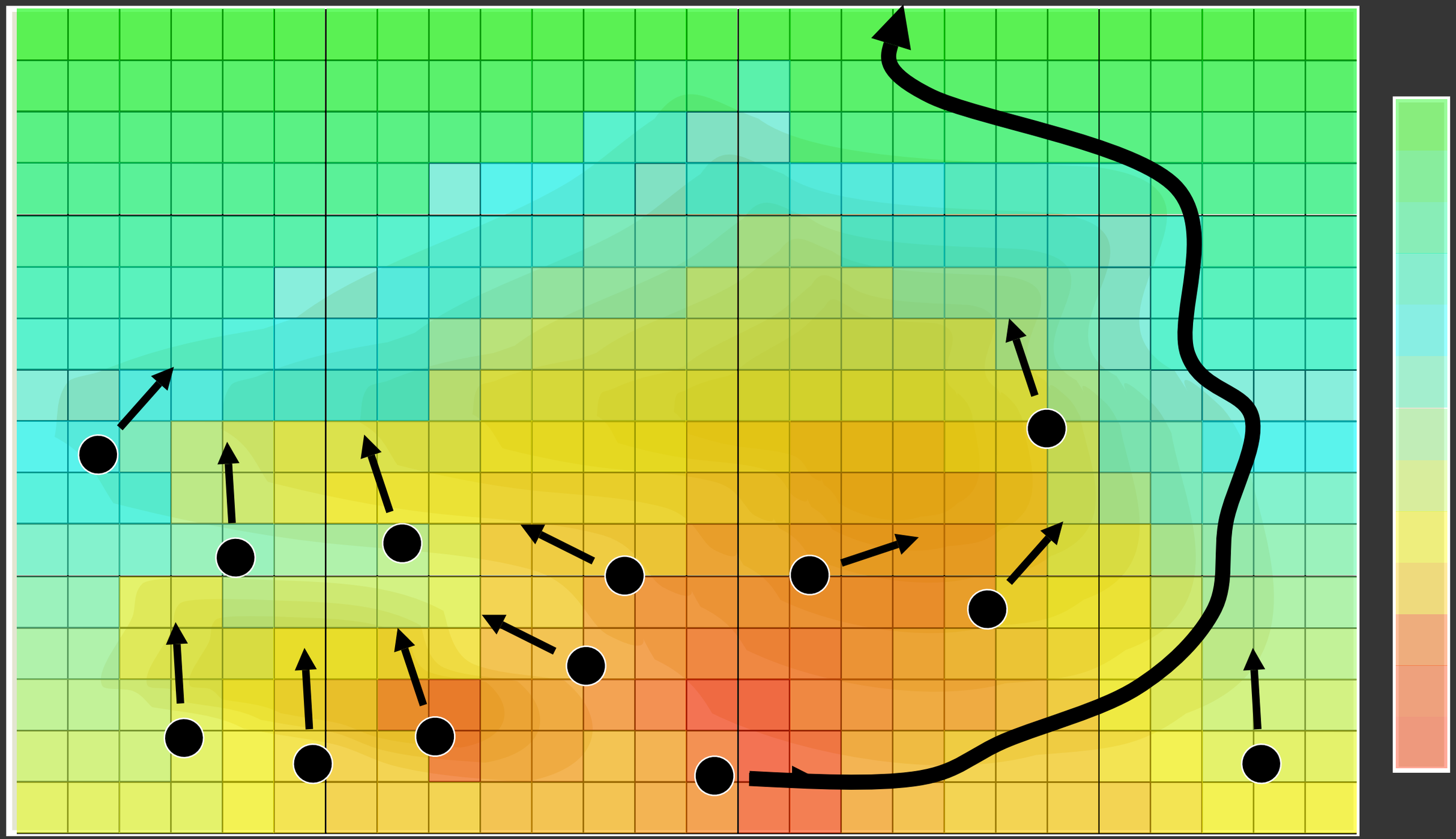
$$\mathbf{f}(\mathbf{v}) = k(\hat{\mathbf{v}} - \mathbf{v})$$

Where does $\hat{\mathbf{v}}$ come from?

Potential

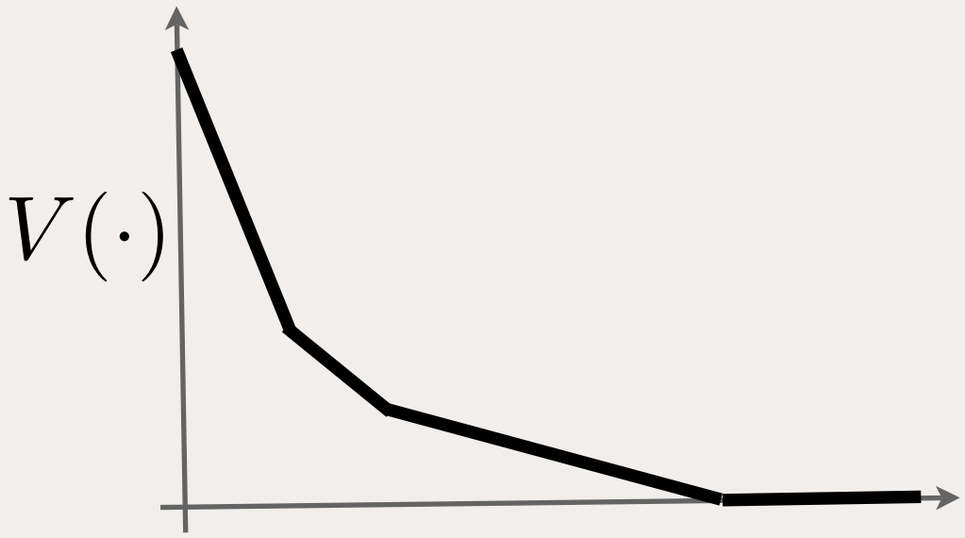


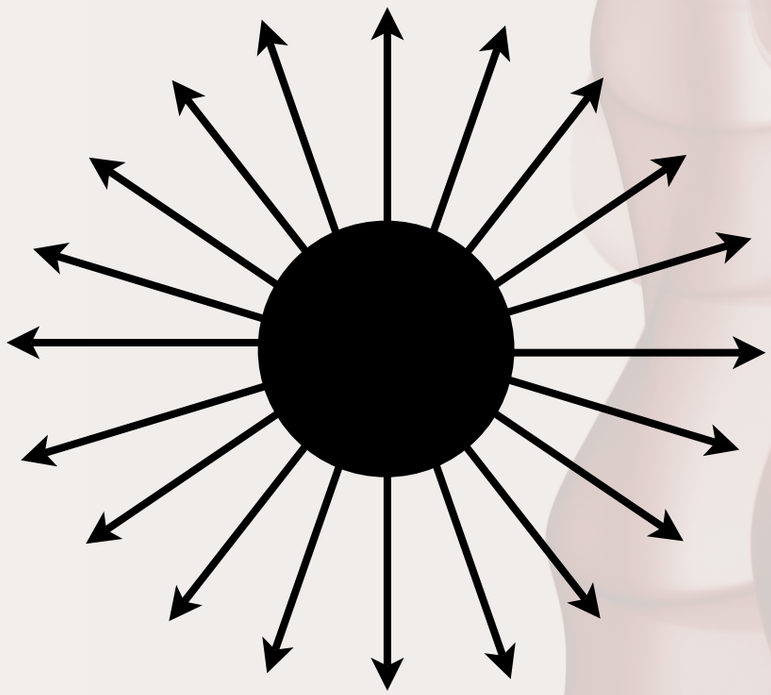
Potential



Obstacle Avoidance

$$\mathbf{f}(\mathbf{x}) = -\nabla V(||\mathbf{x} - \mathbf{b}||)$$





Pedestrian Avoidance

$$f(\mathbf{x}_a, \mathbf{x}_b) = e^{\frac{\mathbf{x}_a - \mathbf{x}_b}{B}} \left(\lambda + (1 - \lambda) \frac{1 + \cos(\phi_{a,b})}{2} \right)$$

Crowds

Source: http://massivesoftware.com/

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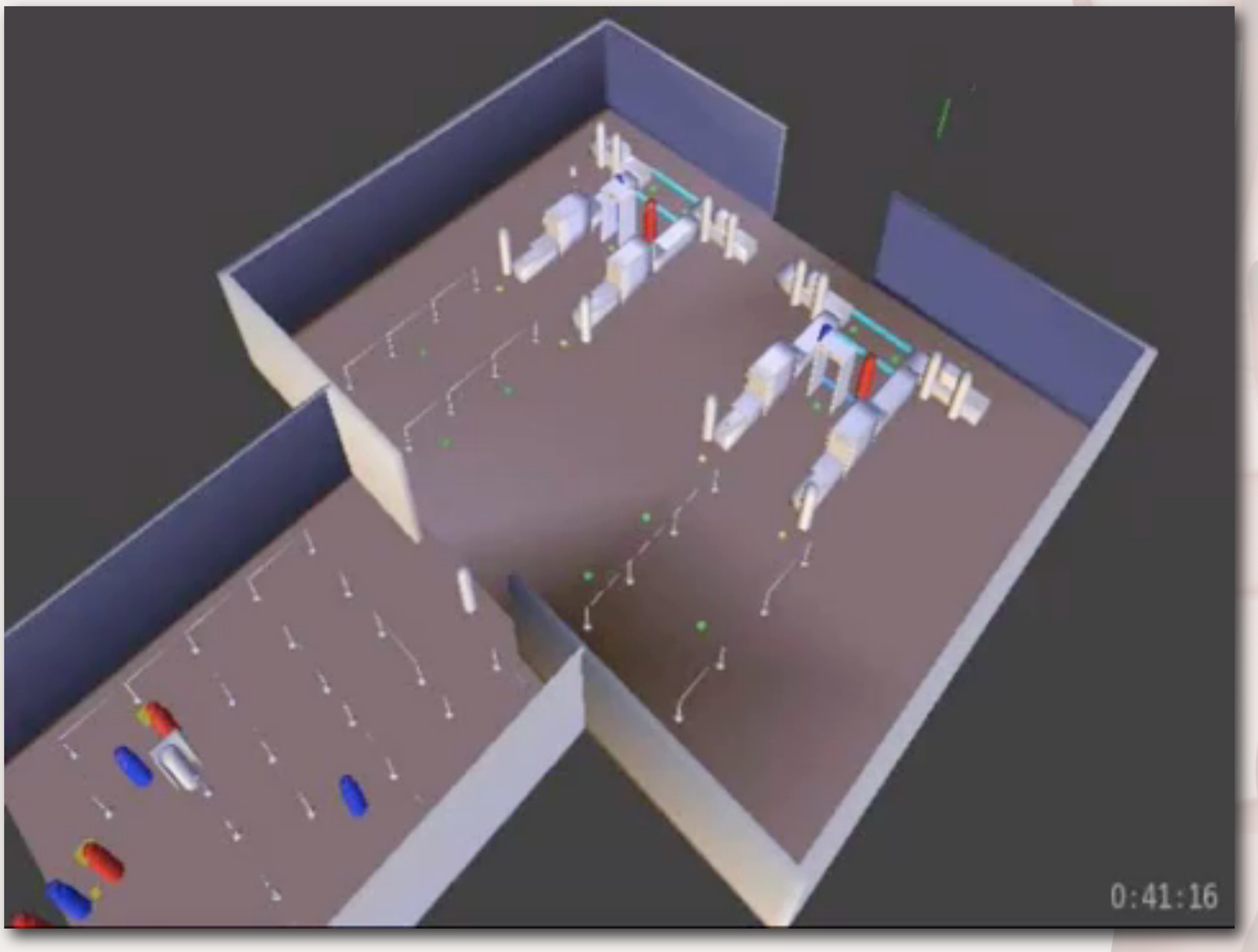
Emergency Planning

Source: http://massivesoftware.com/

Urban Design



Source: http://massivesoftware.com/

Architecture Visualization

Source: http://massivesoftware.com/

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Current Challenges

- **High density crowds.**
- **Motion paths aren't enough.**
  - **Talk with other people.**
  - **Tie their shoes.**
- **Connection with human motion model.**
- **Computational Advantage of Crowd Cohesion**

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Question

- What are the relevant properties of fluids?
- How can these be simulated?
- What phenomena does your algorithm capture, what doesn't it?