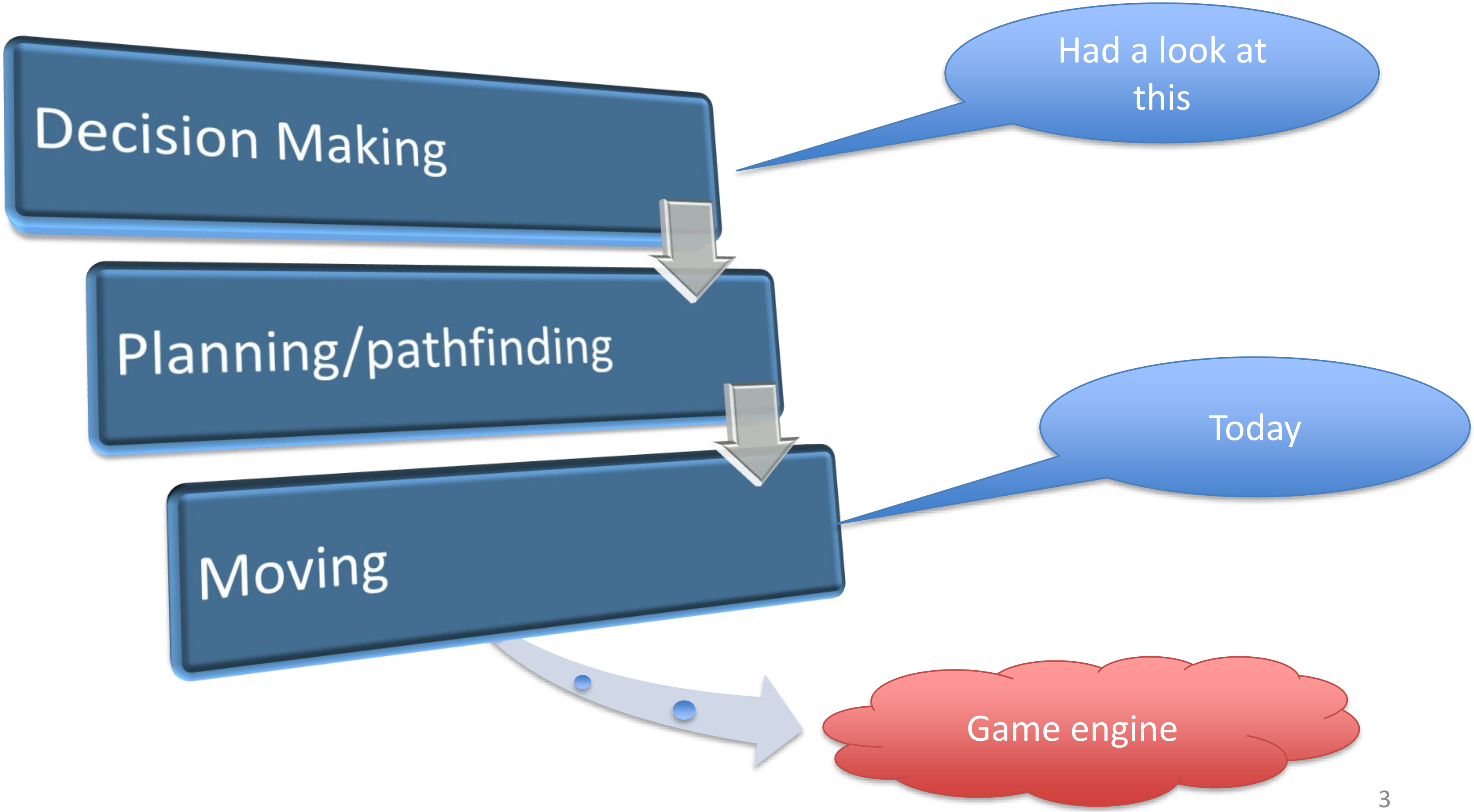
Principles of Computer Game Design and Implementation

Lecture 26

Outline for today

- Steering behavior
  - Character model
  - Simple steering
  - Steering: combining behaviors
  - Steering in real world

A Very Rough Structure of Game AI



Decision Making

Planning/pathfinding

Moving

Had a look at this

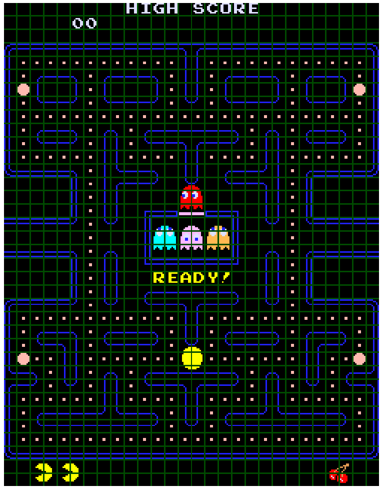
Today

Game engine

The Problem

- Decision making: ***Actions*** to perform
- Game engine models the world
  - One needs to link the levels

- Open space motion
  - No / simple obstacles
  - Select destination and move
    - Bound to succeed
  - ***Pathfinding***



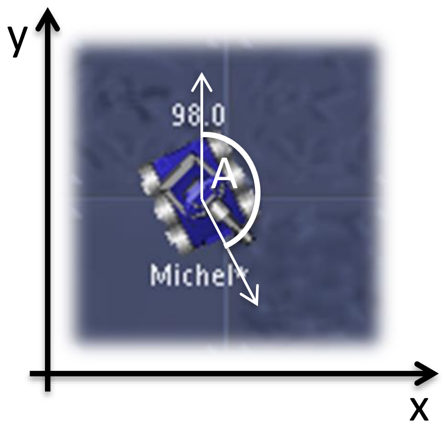
Pac-man: no pathfinding

Motion

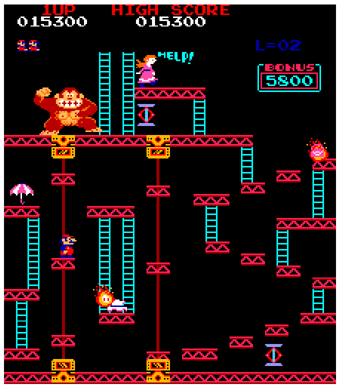
CHARACTER MODEL

Character Position: 2D

```
public class Model {
   Vector2f position;
   float orientation;
   …
}
```



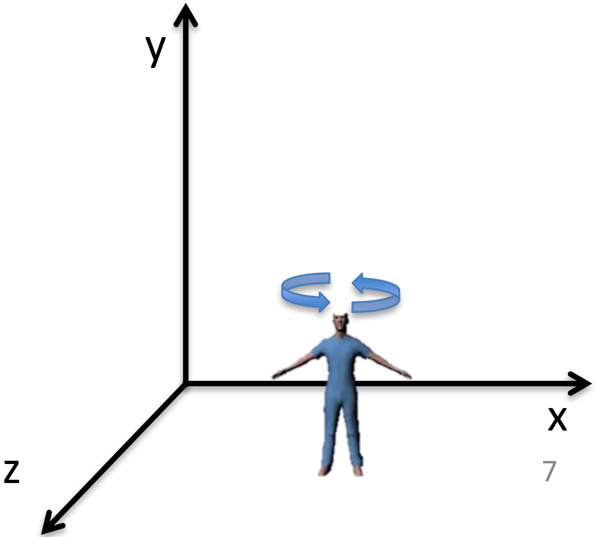
- Robocode
- Real-time strategies
- Platformers



Character Position: $2\frac{1}{2}$D

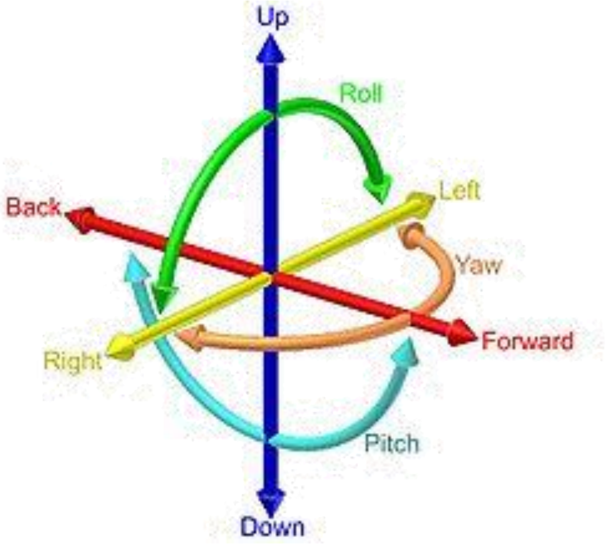
- Full 3D position, but
- Orientation is a single value
  – Character is upright

```
public class Model {
    Vector3f position;
    float orientation;
    …
}
```



True 3D

- All 6 Degrees of freedom (6DOF) are seldom used in practice
  - – Complicated maths
  - – Complicated controls
  - – *Tilts* can be implemented in animation



- Flight simulators / space shooters

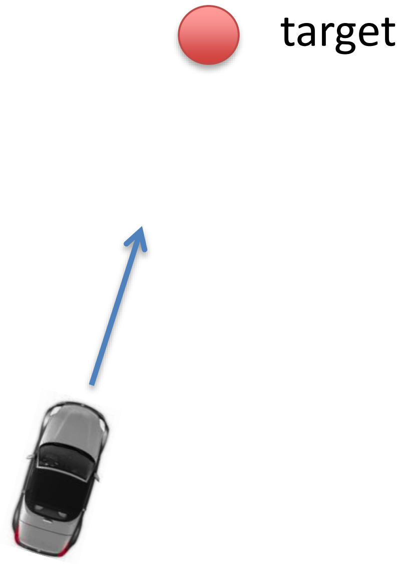
Motion

SIMPLE STEERING

Steering

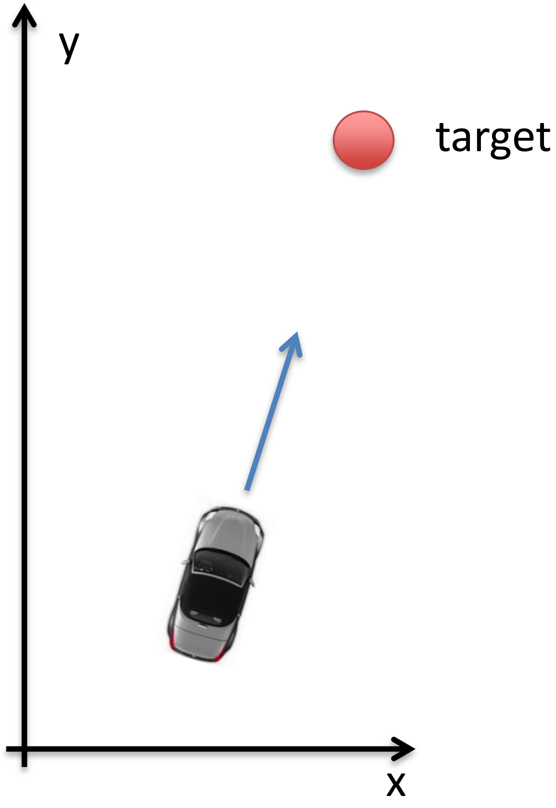
- Two basic strategies
  - Seek
    - Move towards a target
  - Flee
    - Move from target

- Complex **steering**
  - In terms of basic moves



Kinematics vs Dynamics

- Recall: in computer games
  - – Kinematics refers to non-realistic behaviour
  - – Dynamics refers to physics-based motion



Seek: Kinematics

- Direction

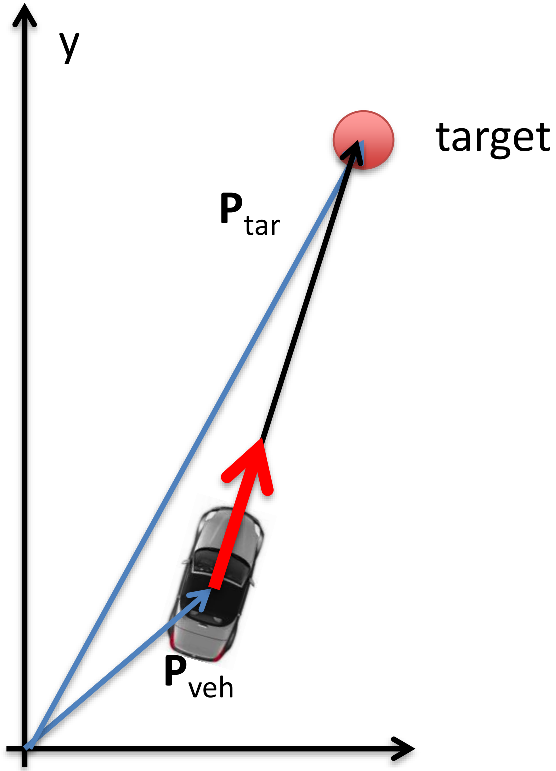
$$\mathbf{D} = \mathbf{P}_{\mathrm{tar}} - \mathbf{P}_{\mathrm{veh}}$$

- Velocity

$$\mathbf{V} = \mathbf{D}.\mathrm{normalise}() * \mathrm{maxSpeed}$$

- Position

$$\mathbf{P}_{\mathrm{veh}} = \mathbf{P}_{\mathrm{veh}} + \mathbf{V}{*}\mathrm{tpf}$$



Flee: Kinematics

- Direction

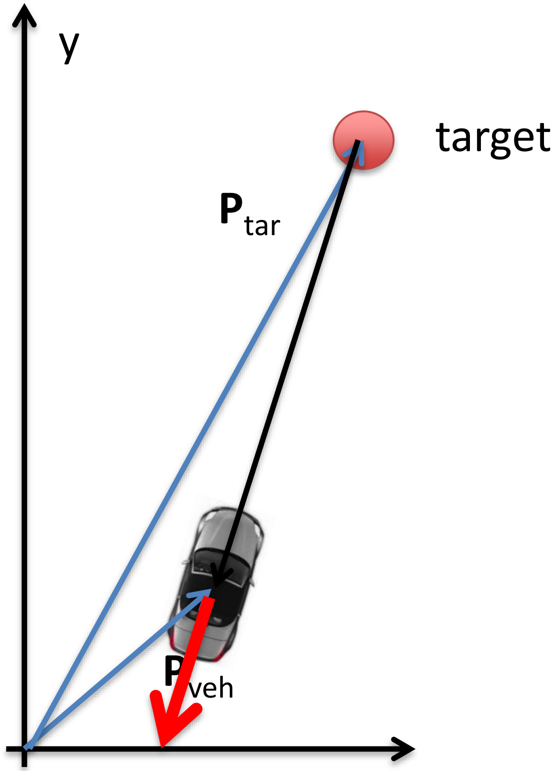
$$\mathbf{D} = -(\mathbf{P}_{tar} - \mathbf{P}_{veh})$$

- Velocity

$$\mathbf{V} = \mathbf{D}.\text{normalise}() * \text{maxSpeed}$$

- Position

$$\mathbf{P}_{veh} = \mathbf{P}_{veh} + \mathbf{V}*\text{tpf}$$



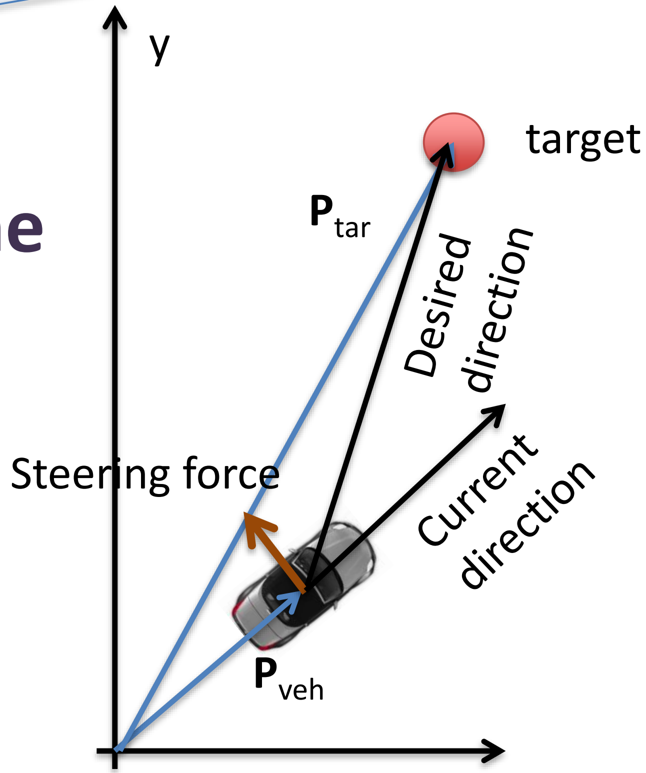
Seek: Dynamics

- Desired direction

$$\mathbf{D} = \mathbf{P}_{tar} - \mathbf{P}_{veh}$$

- *If differs* from current direction, apply a **steering force towards the target**
  - – Use Euler steps
  - – When turning
    - Consider torques
    - Align vehicle with velocity vector

Up to ε

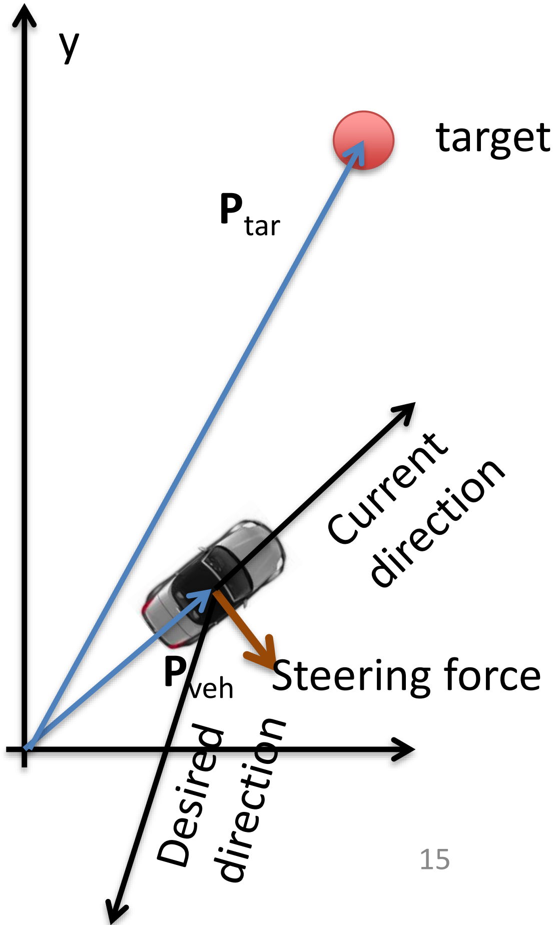


Flee: Dynamics

- Desired direction

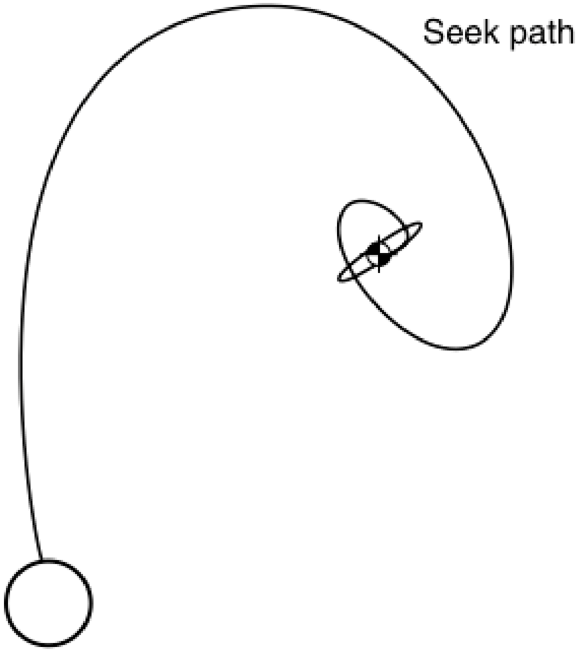
$$\mathbf{D} = -(\mathbf{P}_{tar} - \mathbf{P}_{veh})$$

- *If differs* from current direction, apply **steering force away from the target**



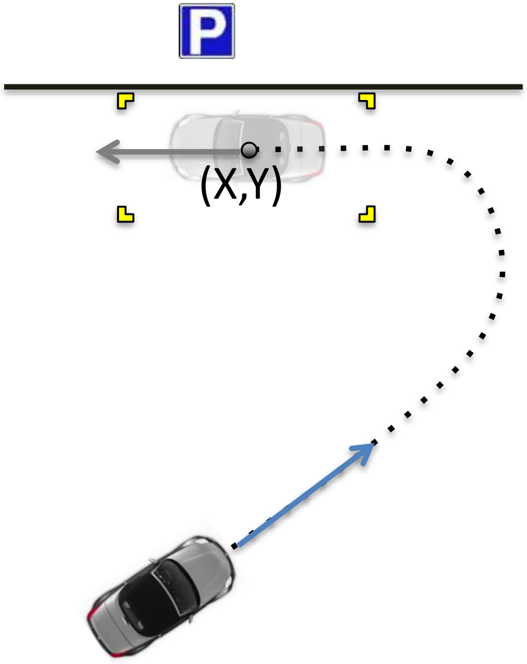
Variation: Arriving

- Moving at high speed can overshoot
  - – No such problem with kinematics
- When close to the target, apply brakes



Variations: Aligning and Facing

- Motion control may need to work closely with the physics engine
  - Aligning
    - Match agent's velocity with target velocity (pursuing)
  - Facing
    - Arrive facing a direction



Complex Behaviours

- Pursue / evade
- Wander
- Separation
- Path following

Defined in terms of

- Seek / Flee
    - arriving, aligning, facing

Pursue or Intercept

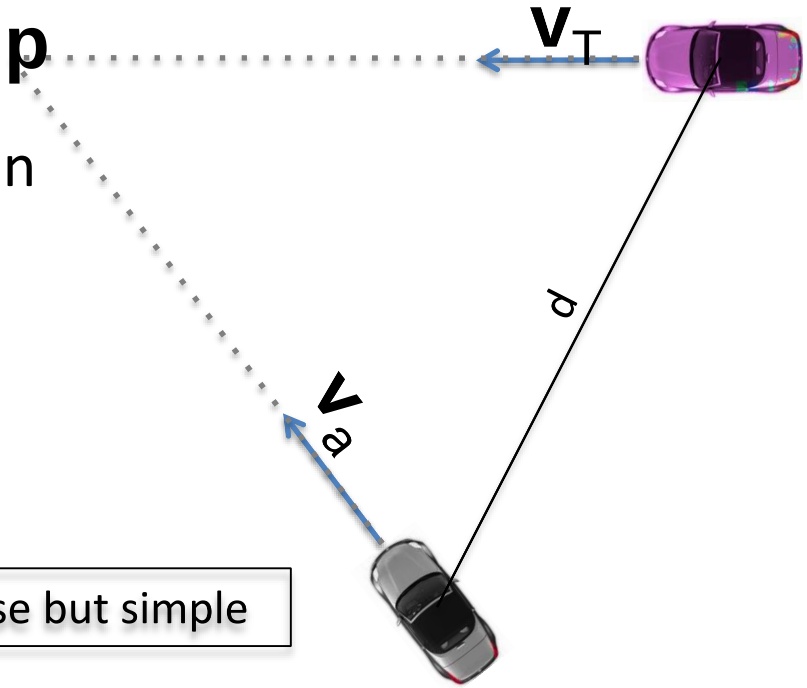
- Go where target will be
  - Assume target speed does not change
    - Calculate time to get where the target currently is

$$t = d/v_a$$

    - Calculate the target position after this time passes

$$\mathbf{p} = \mathbf{v}_T t$$

    - Drive there
      - `Seek(p)`

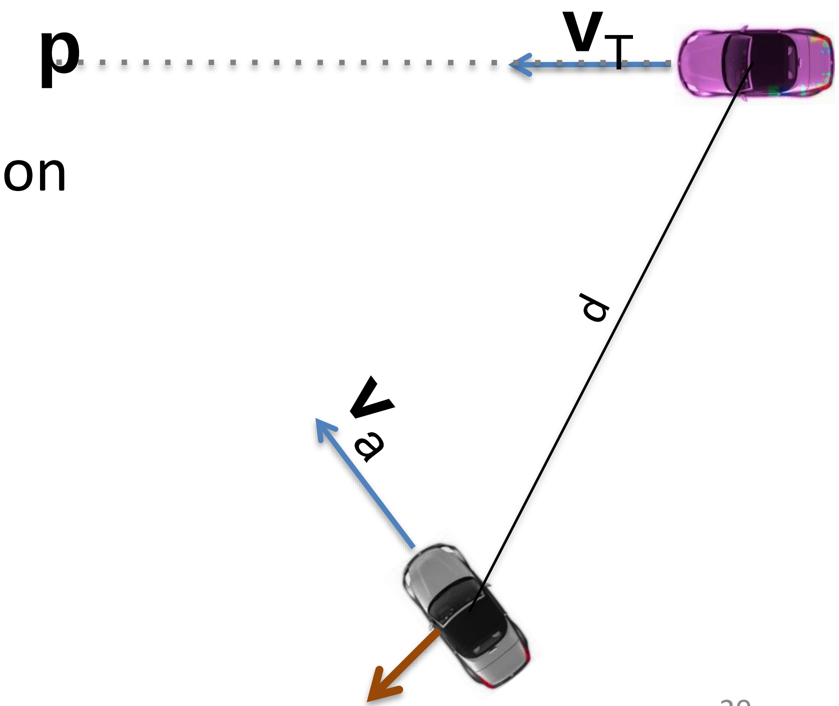


Imprecise but simple

Evade

- Go away from where target will be
  - Assume target speed does not change
    - Calculate time to get where the target currently is

$$t = d/v_a$$



- Calculate the target position after this time passes

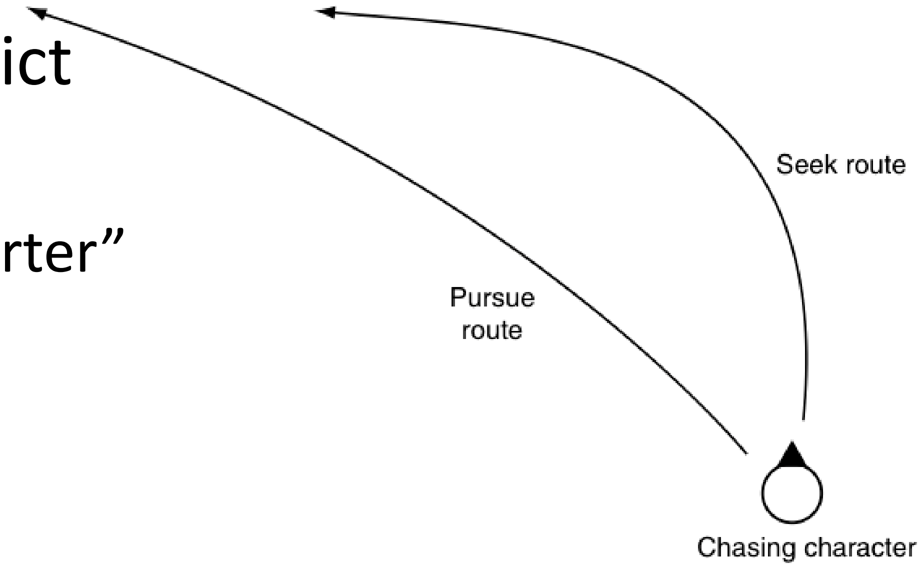
$$\mathbf{p} = \mathbf{v}_T t$$

- Drive from there
  - `Flee(p)`

Pursuing an Evading Target

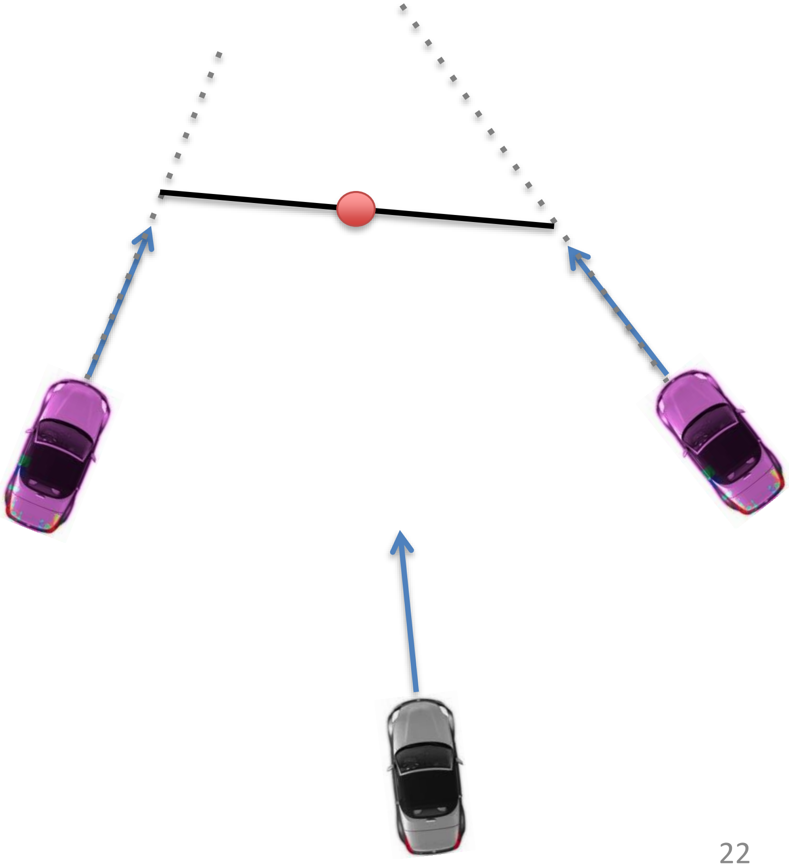
Target's speed is not constant

- Normally, cannot predict
  - Recalculate position
  - No point to use a "smarter" technique



Interpose

- Steer to midpoint of line connecting bodies
  - Bodyguard taking a bullet
  - Goalkeeper

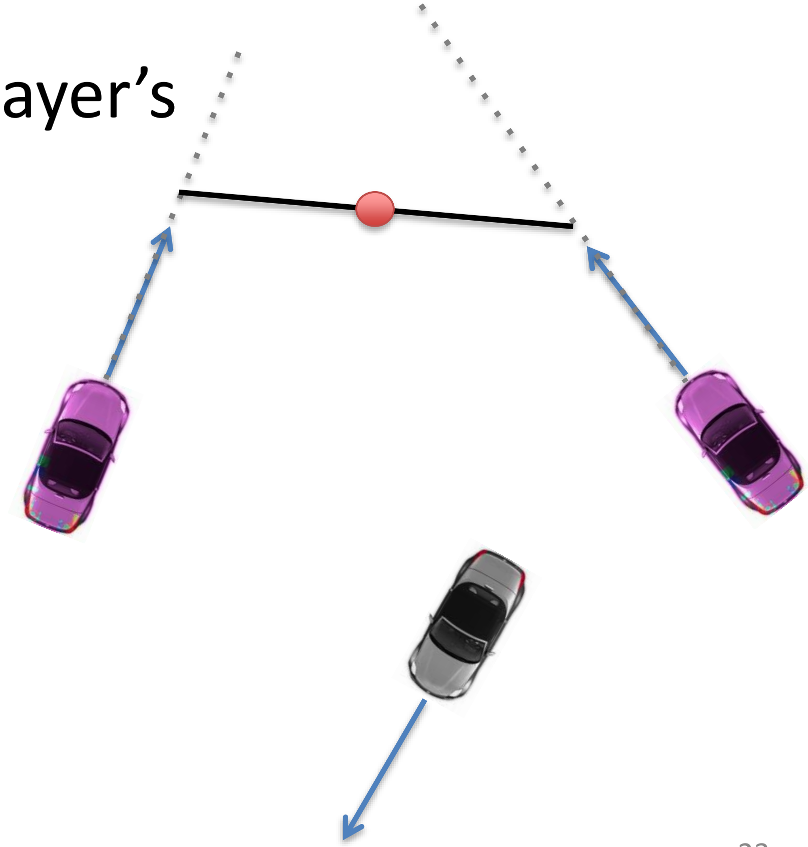


- Similar to pursue

Opposite to Interpose

- Steer away from midpoint of line connecting bodies
  - Not standing in human player's line of view
  - Not taking the lead
    - Squad behaviour

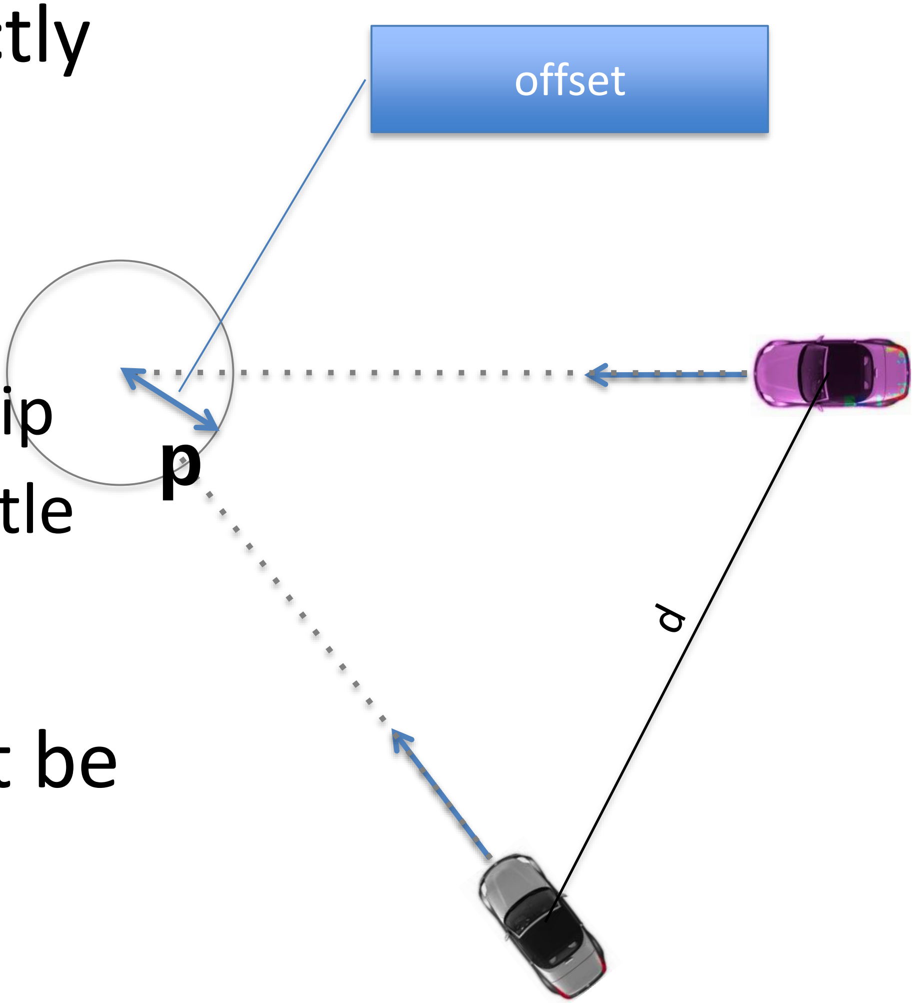
- Similar to evade



Pursue / Interpose with Offset

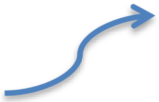
- Pass near but not directly into a target
  - Pursue within weapons range
  - Docking with a spaceship
  - Follow a leader in a battle formation

- Speed alignment might be necessary

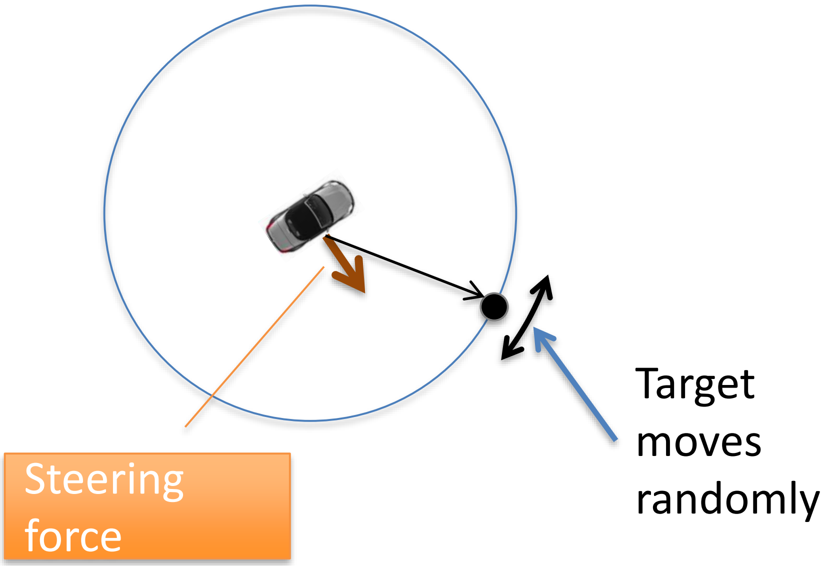


Wander

1. Random steering forces
   - “wobble” around a straight line

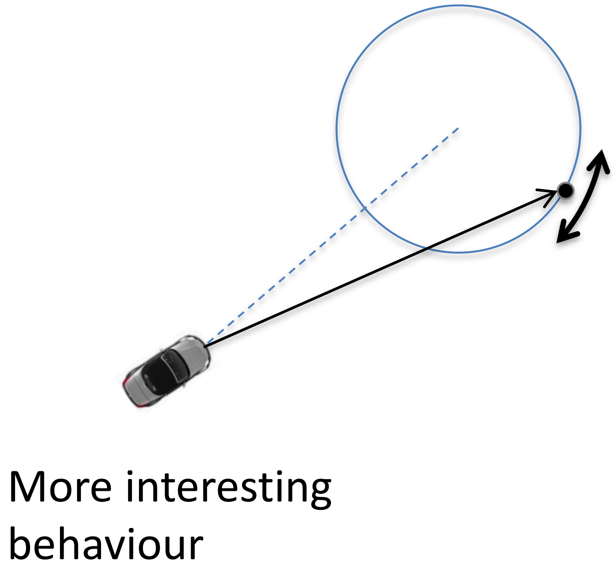


2. *Seek* a randomly moving target



Steering force

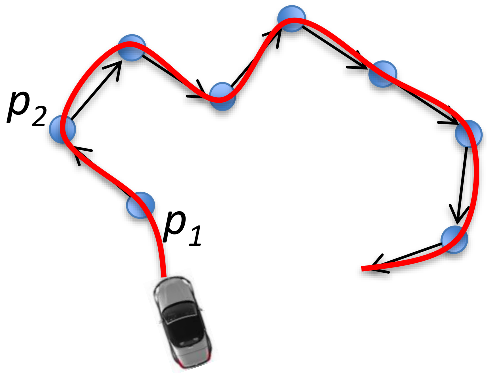
Target moves randomly



More interesting behaviour

Following Paths

- ***Path***: a series of *waypoints*
  - Can be open or closed (looped)
  - Locate the closest point p_1
  - Seek(p_1)
  - When close to p_1
  - Seek(p_2)
  - …



Following a racetrack

Motion

STEERING: COMBINING BEHAVIOURS

Combining Steering Behaviours

- Police car:
  - Pursue
  - Avoid obstacles

- Animal
  - Wander
  - Avoid obstacles
  - Evade predatorss

Techniques

- Blending
  - Collect steering forces from ***all*** methods

$$\mathbf{F} = w_1\mathbf{F}_1 + w_2\mathbf{F}_2 + \ldots$$

Resulting steering force

- Priorities
  - Sort steering methods by priority
  - If higher priority method applies, use it **and stop evaluation**
- Hacks

Blending Example: Flocking

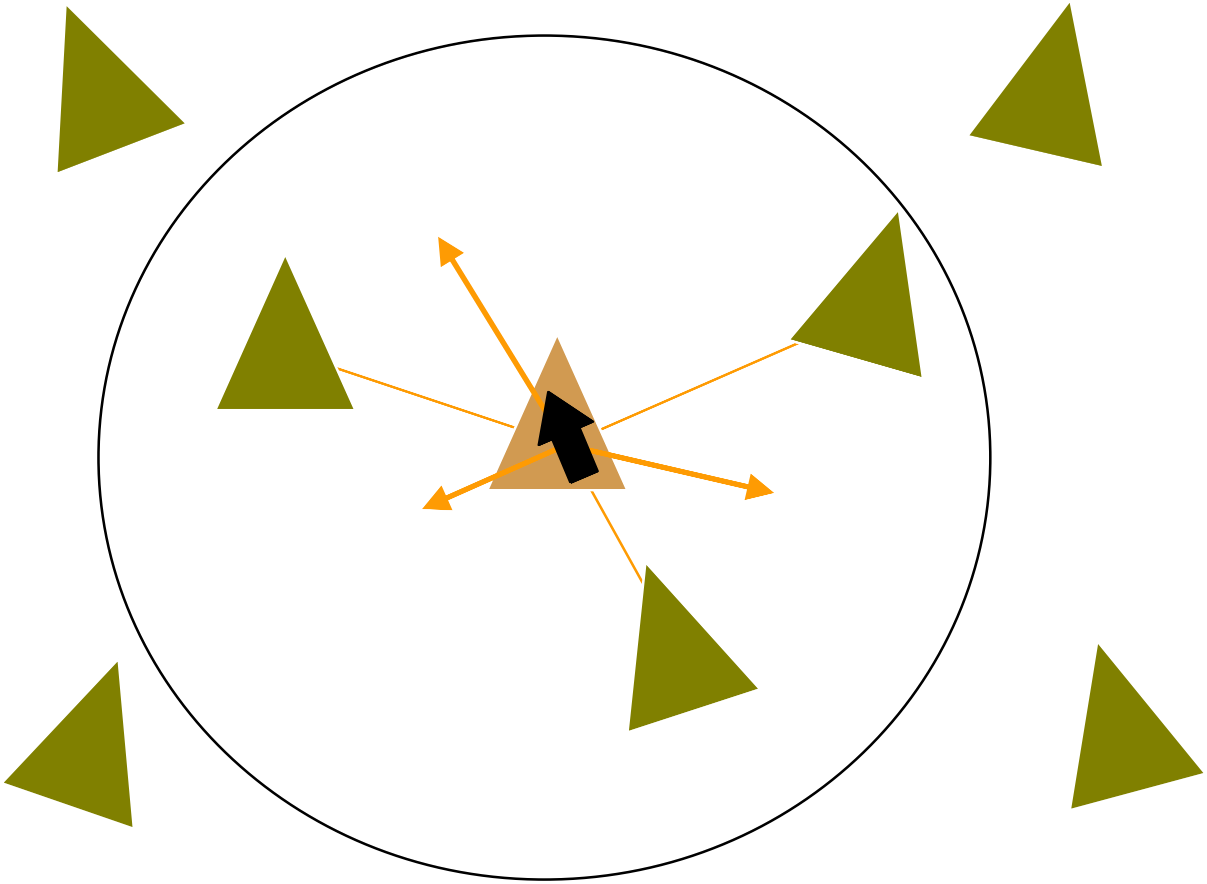
- A combination of :
  - **Separation**
  - **Alignment**
  - **Aggregation**

produces believable results

- “Batman returns” (bats & penguins) and other movies

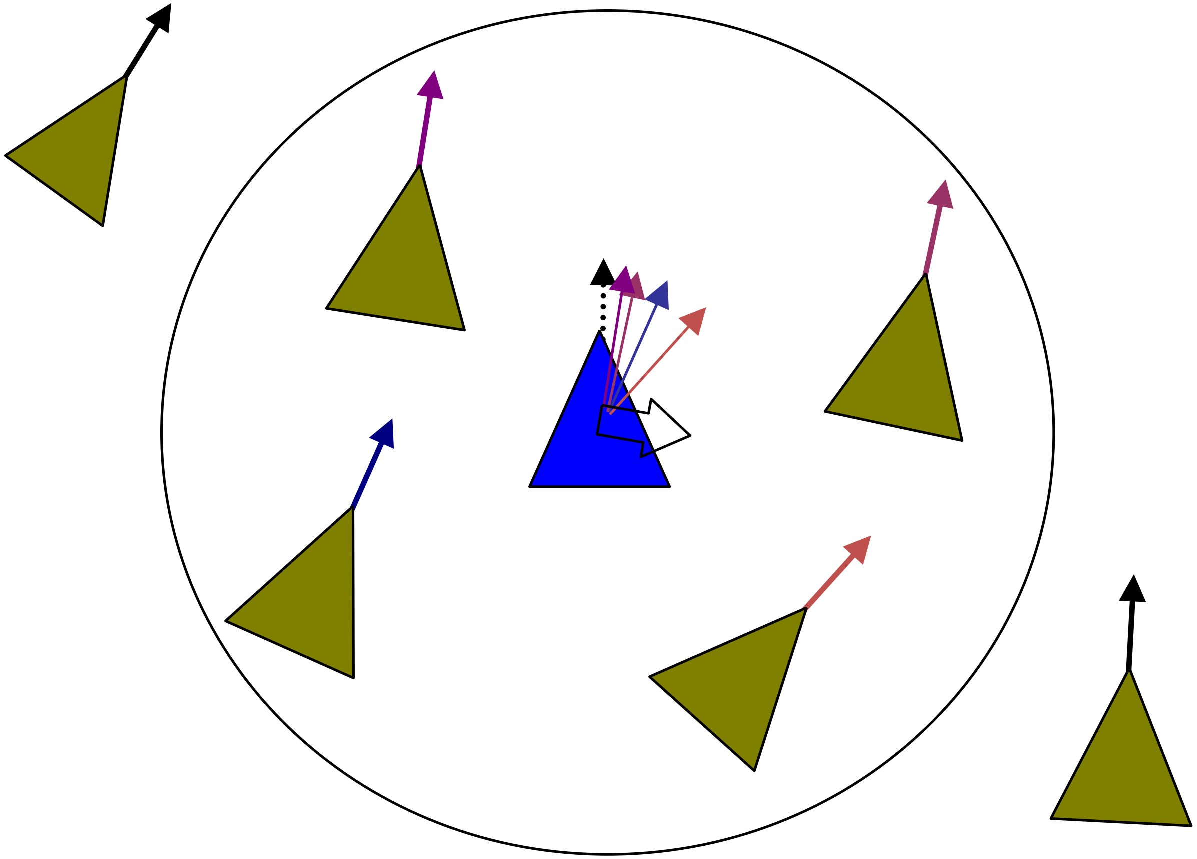
Separation: Boid Avoidance

Move away from the boids too close



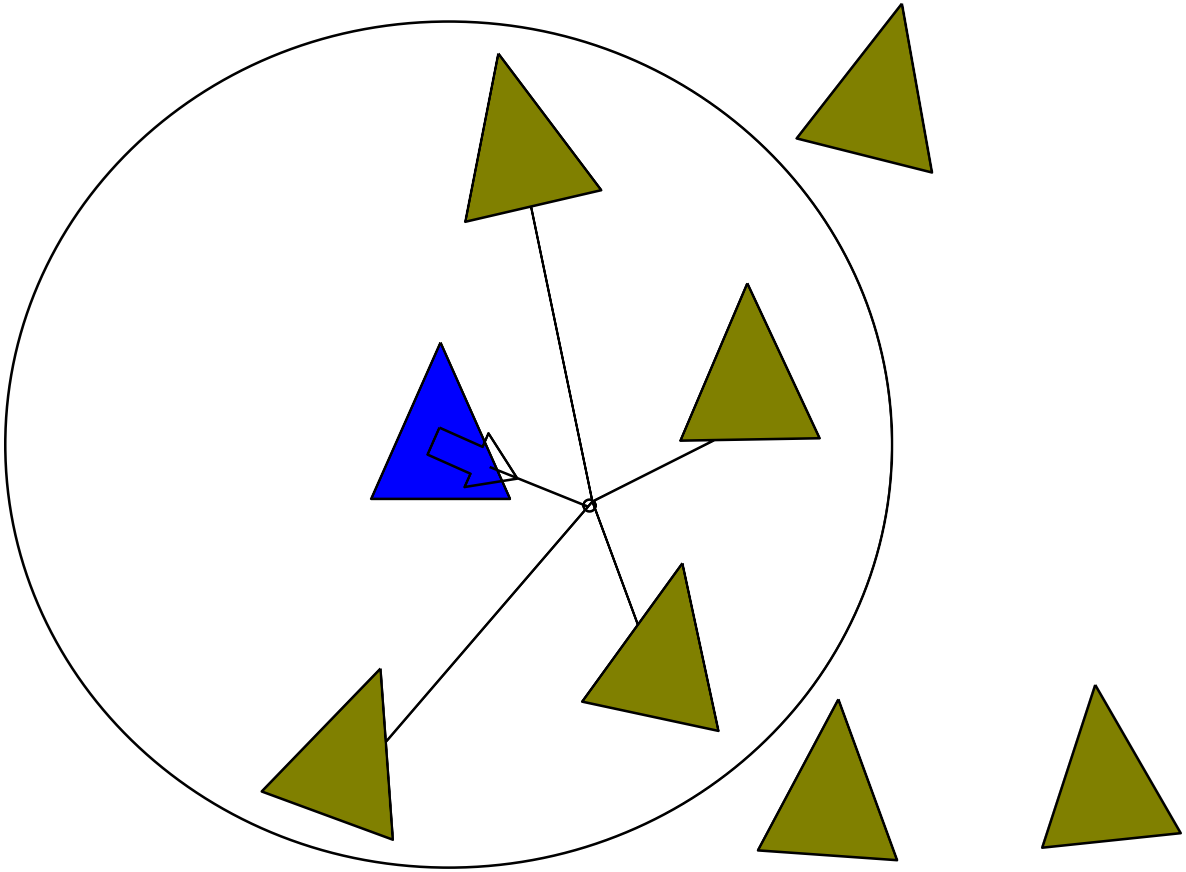
Alignment

Move in the same direction and the same velocity as the flock



Aggregation

Move towards the centre of mass of the flock

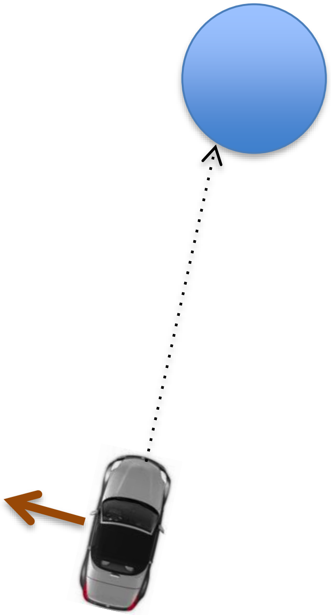


Motion

STEERING IN REAL WORLD

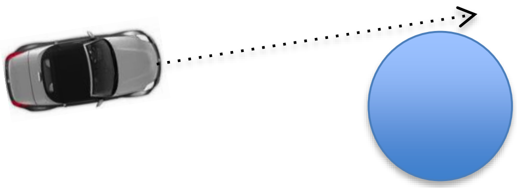
Collision Avoidance

- Cannot assume motion in open space
- *Steer around obstacles*
  - Cast a ray in the direction of motion
  - If collides with an obstacle
    - Apply a steering force
      - *Flee* until avoid collision
  - Avoids *nearest* obstacle
  - Won't work in really complicated environments

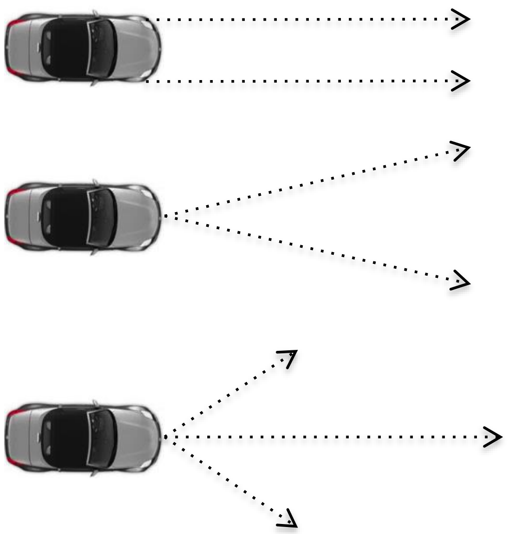


Ray Casting

- Single ray does not notice the obstacle

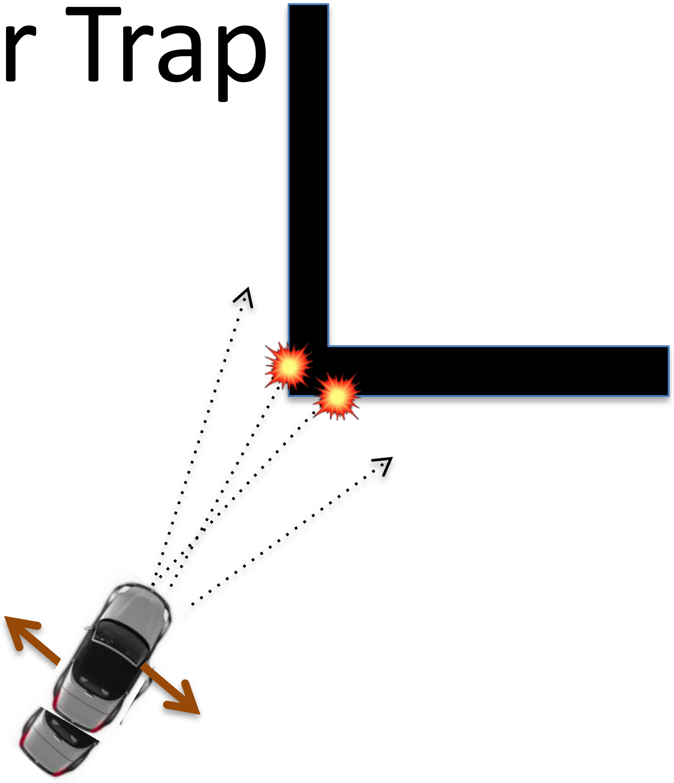


- Variations:
  - Parallel side rays
  - Whiskers
  - Central ray + whiskers



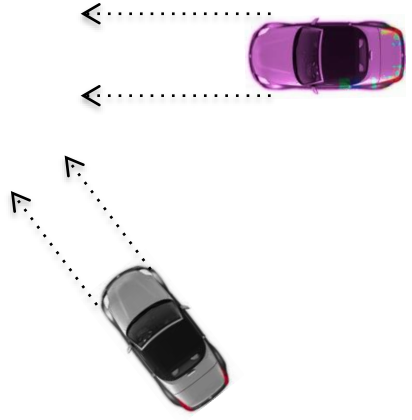
Problems: Corner Trap

- Can happen with any number of rays
  - Adaptive fans
  - Special treatment of corners



Problems: Collisions with Other Movables

- Cannot avoid collision based on simple overlap test
- Collision prevention based on the intersection test is needed



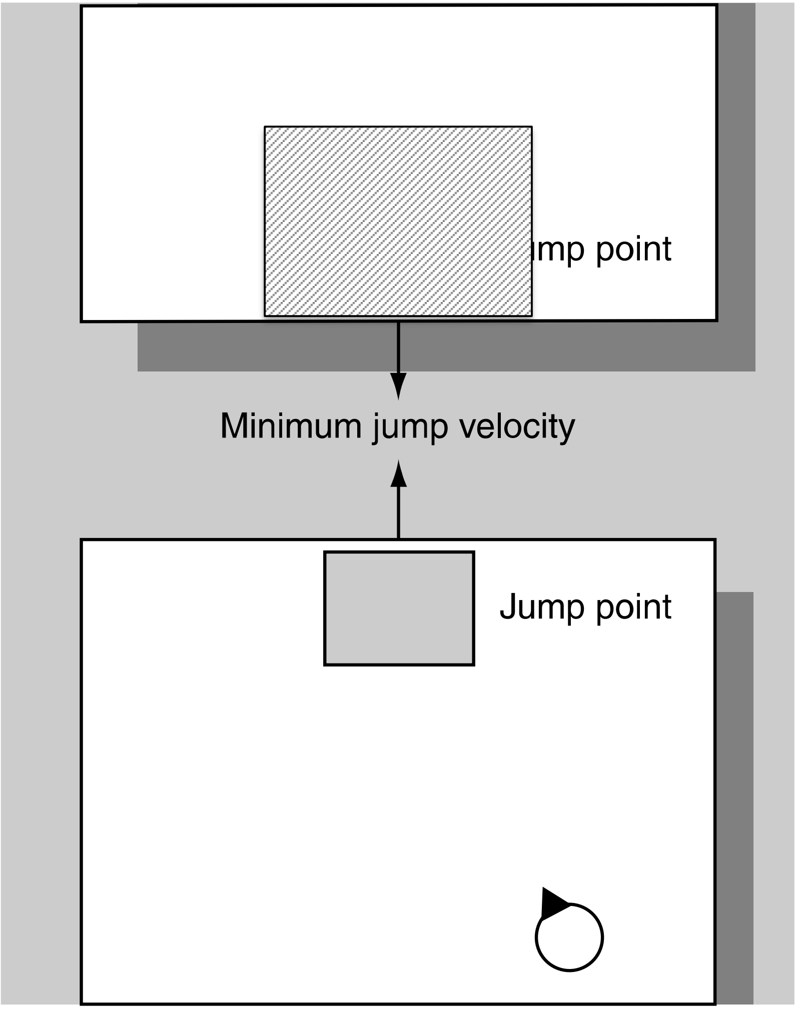
Jumping

- Shooter games often use kinematics rather than dynamics for humanoids
- Jumping, however, is where this should not happen
- Tasks:
  - Locating a narrow passage to jump over
  - Selecting direction of jumping
  - Adjusting speed

Jump Points

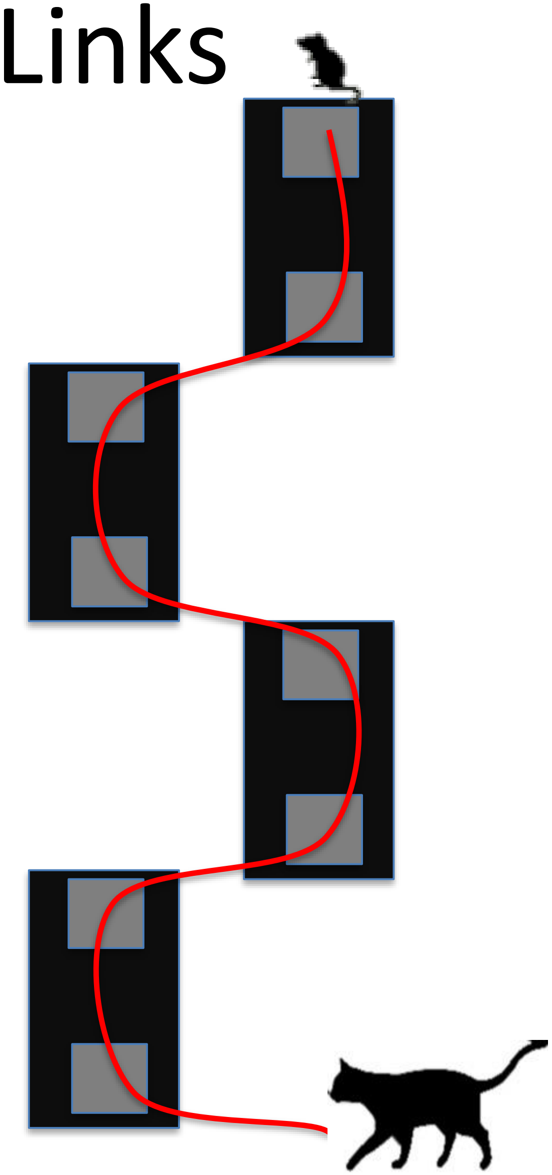
- Level designer to decide where to jump
  - Speed alignment
  - Face
  - Seek

- Landing pads

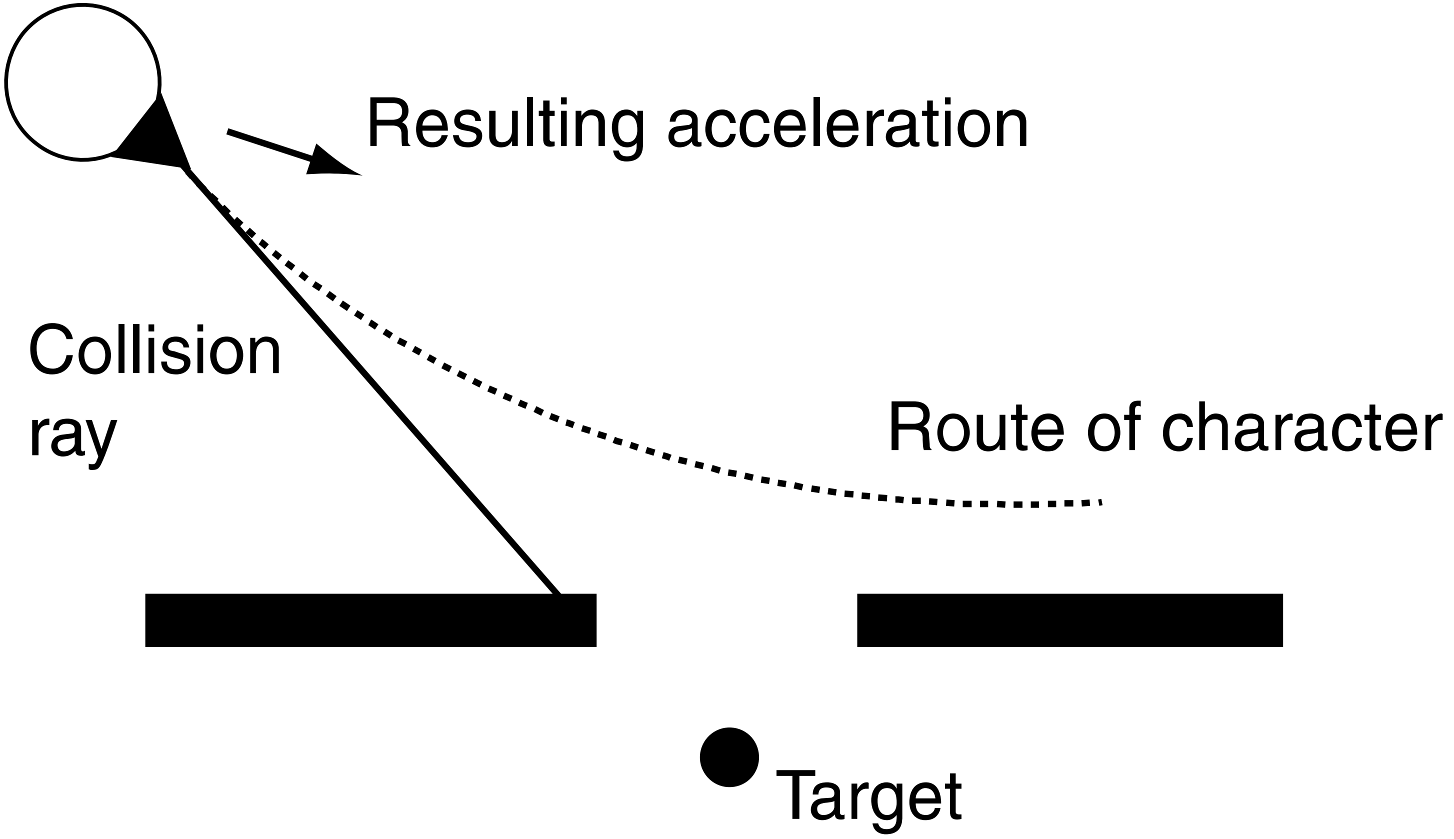


Problems: Jump Links

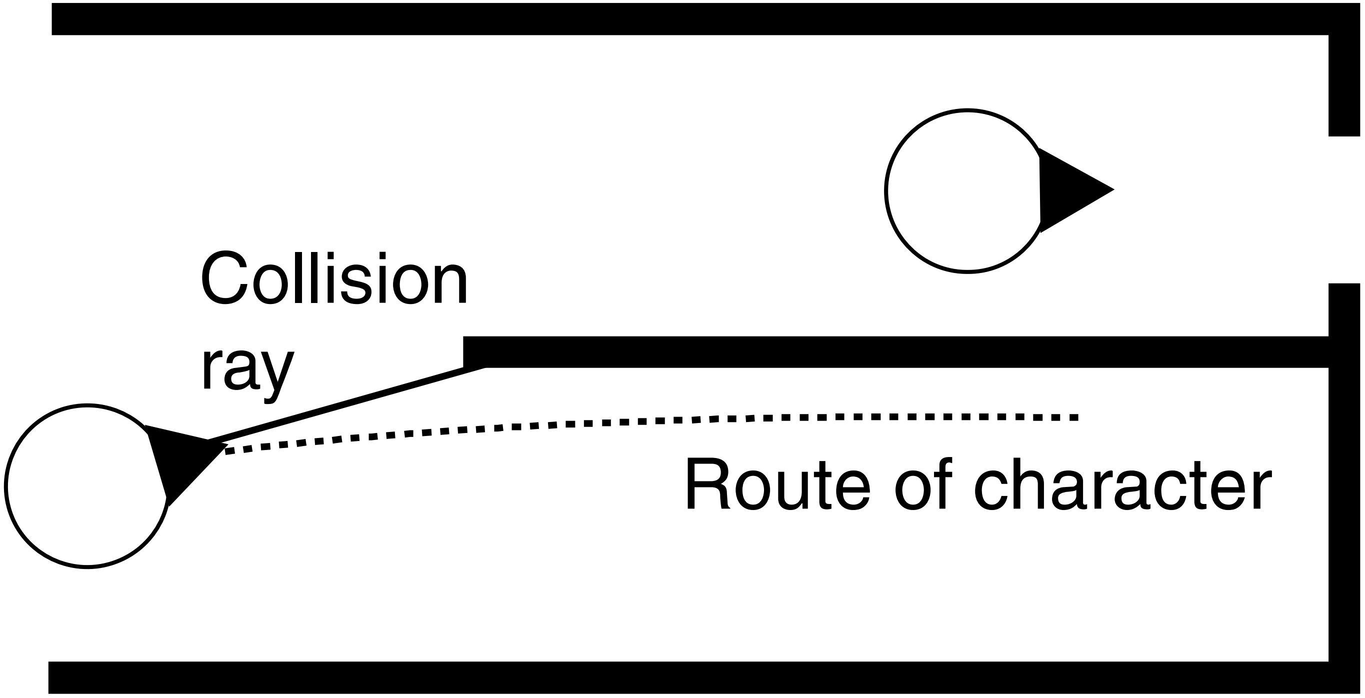
- When pursuing a target, have to move in a different direction
  - – Jump links



Steering Fails: Narrow Doorways



Steering Fails: Long Distance



Summary

- Steering is a powerful motion control mechanism

- Complex behaviours can be constructed from simple ones

- In some circumstances characters need a **path** to follow