Faculty of Mathematics and Physics
Charles University
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Artificial Intelligence for Computer Games

Local Navigation

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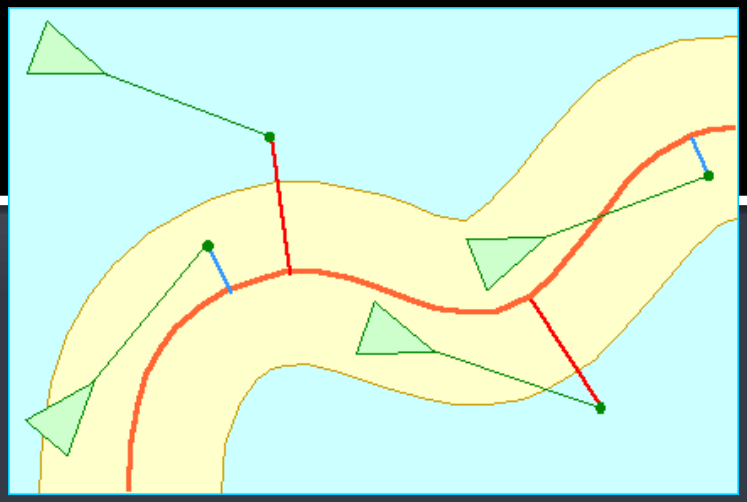
Moving around smoothly



https://www.red3d.com/cwr/steer/

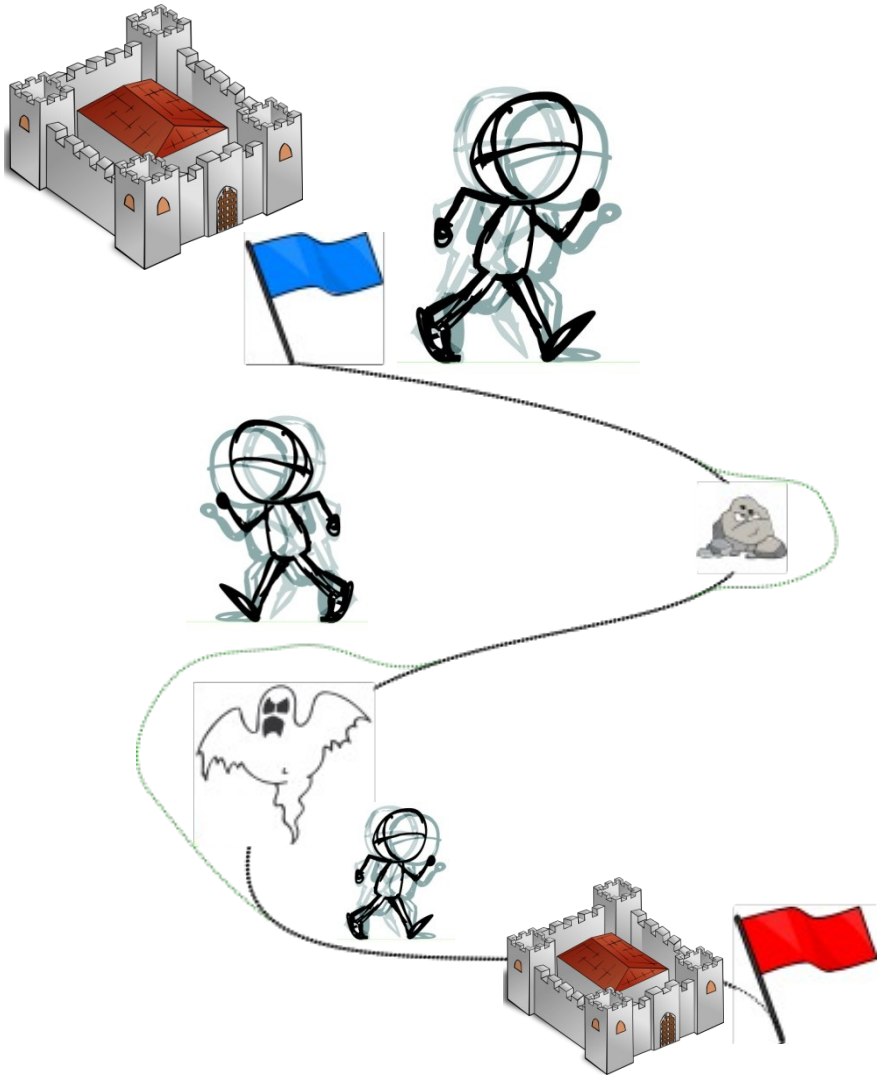
Steering Behaviors
As part of navigation

1. Action-Selection
Strategy => Goals

2. Path-planning
List of path-points

3. Path-determination or Path-following
What path to take exactly

4. Animating
Animation sequencing



Steering Behaviors
What are they?

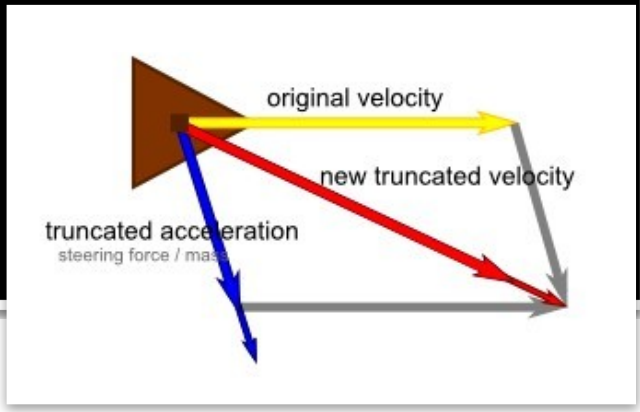
- A framework for controlling low-level movement of autonomous agents == means of locomotion
  - Works with forces that are adjusted every frame
    - Can be easily combined
    - Computationally cheap (sum of vectors) wrt. planning
    - Produces smooth paths
    - Sometimes hard to parametrize
  - Local technique; does not plan, does not foresee procedurally, just projecting current velocity
    - But can be combined with path planning
  - Works per agent but exhibit emergent group behaviors

Steering Behaviors
Where do they come from?

- **Invented by Craig Reynolds around 1983**
- Flocks, herds and schools: A distributed behavior model (SIGGRAPH, 1987)

  >9000 citations!
- Steering behaviors for autonomous characters (GDC, 1999)
  - https://www.red3d.com/cwr/papers/1999/gdc99steer.pdf
  - A classic source now
- https://www.red3d.com/cwr/steer/
  - Java applets demonstrating steering behaviors

Steering Behaviors
Vehicle model




```
1.  accel = steering.calculate(args)
2.  accel = clampLen(accel, MAX_ACCEL)
3.  velocity = velocity + accel * timeDelta
4.  velocity = clampLen(velocity, MAX_VELOCITY)
5.  position += velocity * timeDelta
6.  look-direction = normalize(velocity)
```

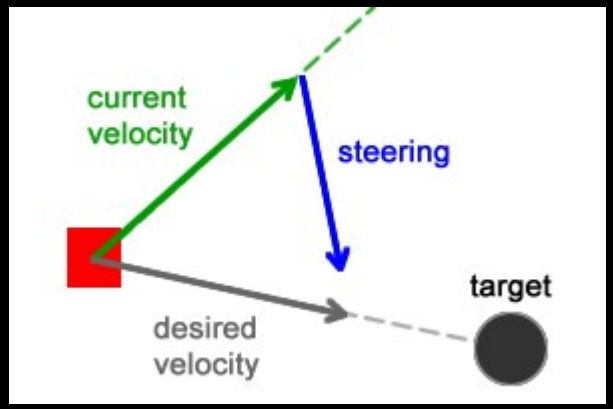
Steering Behaviors
List of Reynold steerings

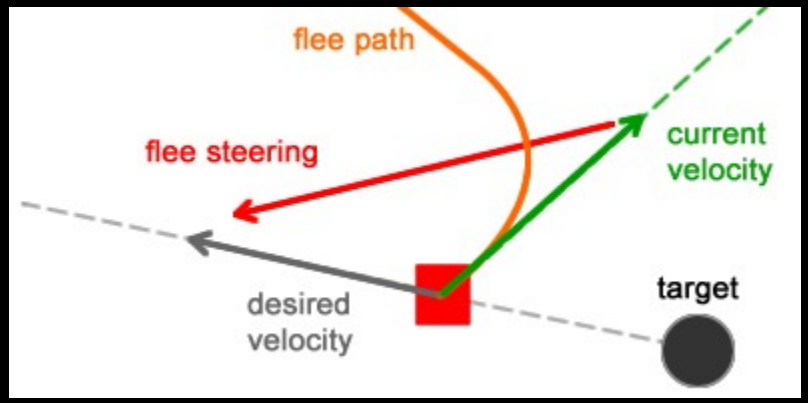
1. `accel = steering.calculate(args)`

   - Many different steering behaviors may take place here
   - Simple behaviors for individuals and pairs:
     - Seek and Flee
     - Pursue and Evade
     - Wander
     - Arrival
     - Obstacle Avoidance
     - Containment
     - Wall Following
     - Path Following
   - Combined behaviors and groups:
     - Flocking (combining separation, alignment, cohesion)
     - Crowd Path Following
     - Leader Following
     - Unaligned Collision Avoidance

Seek & Flee

- Seek
  - steers agent towards a static target
- Flee
  - steers agent away from a static target



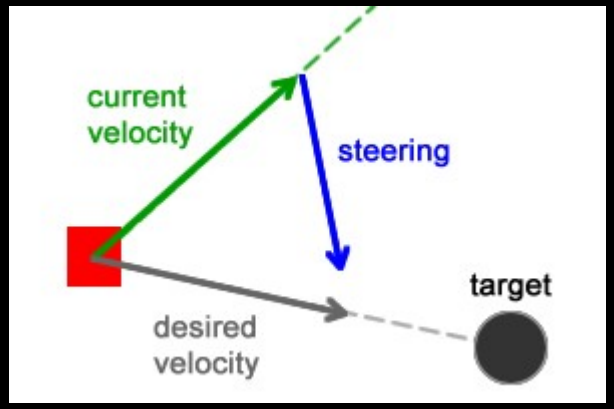


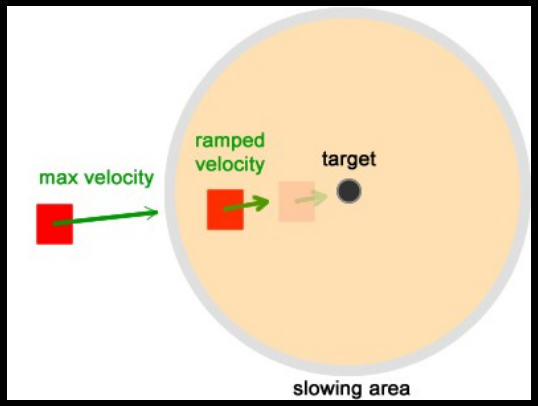
Seek steering force computation

```
1. to_target = target_position – my_position
2. desired_velocity = normalize(to_target) * MAX_SPEED
3. accel = (desired_velocity – velocity) * MAX_ACCEL
```

Arrival

- Like Seek, except the agent slows down as it approaches a static target
- Agent starts decelerating once it enters the slowing area
- **Slowing distance** d is the distance to decelerate to a full stop
- Let v_{max}, a_{max} be maximum velocity, acceleration
  - Time to decelerate = v_{max} / a_{max}
  - Average speed during deceleration = $v_{max} / 2$
  - so $d = (v_{max} / a_{max})(v_{max} / 2) = v_{max}^2 / (2\, a_{max})$



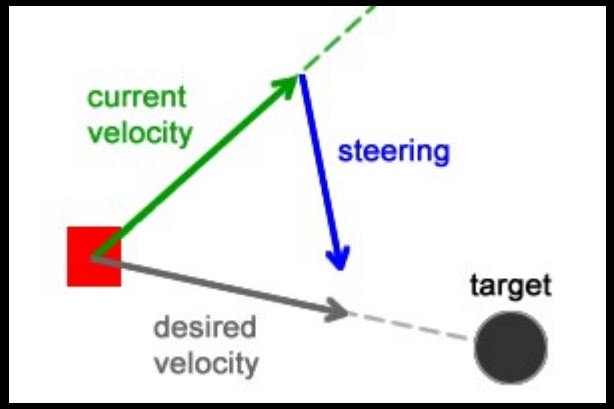


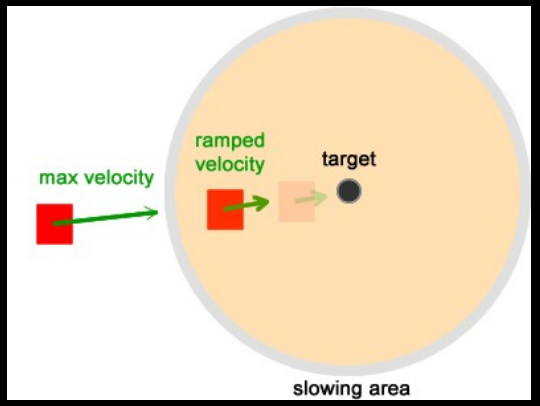
Arrival

- Like Seek, except the agent slows down as it approaches a static target

Arrival steering force computation

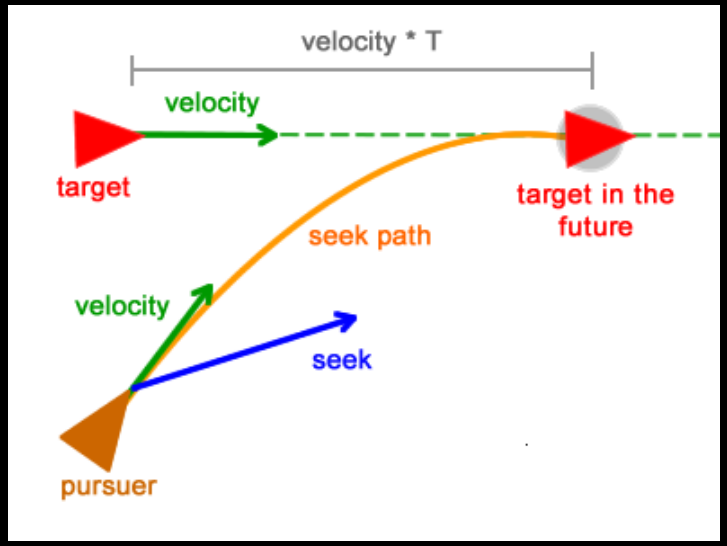
```
1. to_target = target_position – my_position
2. distance = length(to_target)
3. ramped_speed = max_speed * (distance / slowing_distance)
4. clipped_speed = min(ramped_speed, max_speed)
5. desired_velocity = to_target * (clipped_speed / distance)
6. accel = normalize(desired_velocity – velocity) * MAX_ACCEL
```





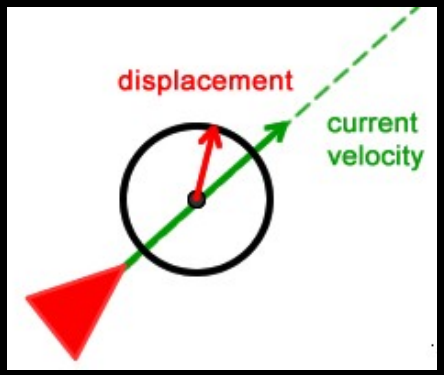
Pursue & Evade

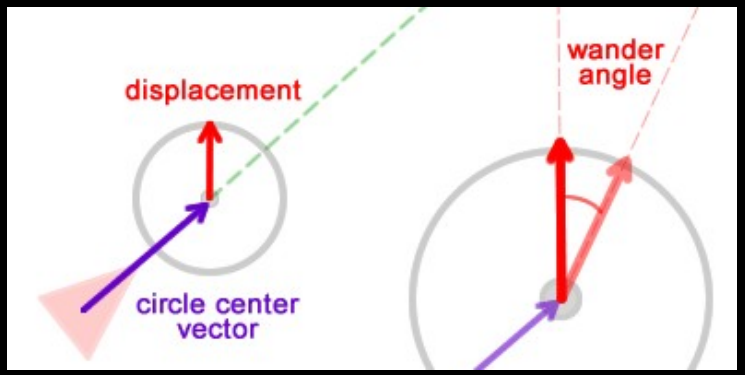
- As seek & flee, except the target moves - **target is <u>dynamic</u>** this time
- Agent predicts the location of the target in the future
- Prediction based on target velocity & time *T* to reach target
  - How to calculate *T*?
  - Possible approximation: time to reach current target pos at max velocity

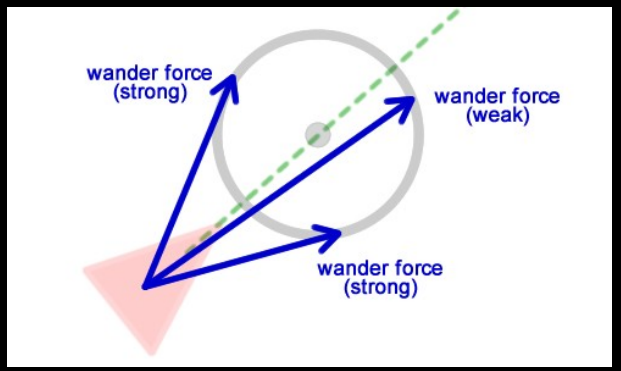


Wander

- Type of random steering: the steering direction on one frame **is related** to the steering direction on the next frame
- More believable than totally random steering forces
- Steering force:
  - At each time step a random offset is added to the wander direction
  - The modified wander direction is constrained to lie on the big circle
- Constriction of the offset: small circle
- Constriction of the steering: big circle







Steering Behavio

Inspiration

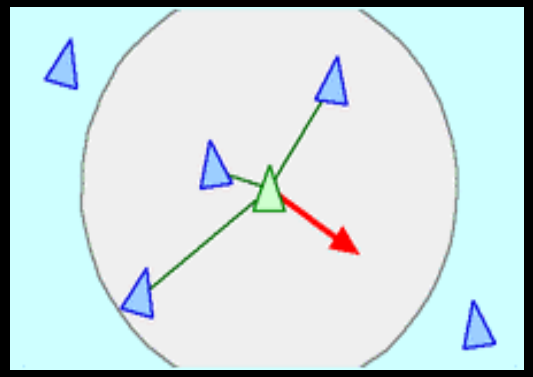
https://www.youtube.com/watch?v=V4f_1_r80RY

Flocking Model of Boids

- Bird like object (Boid); 3 steering rules to combine

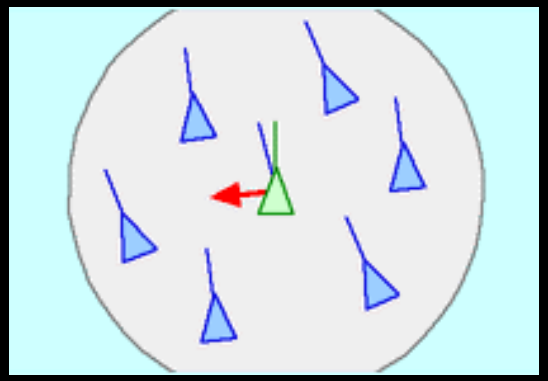
Separation

- Do not get too close to nearby flockmates, so steer away from them
- Separation force inversely proportional to distance



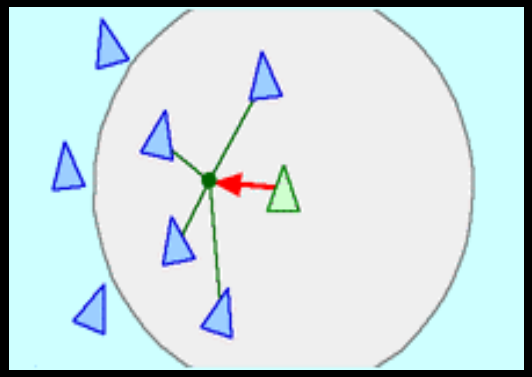
Alignment

- Try to move at the same speed and direction (velocity) as nearby flockmates
- Steers boid to have the same velocity as the average of velocities of nearby flockmates



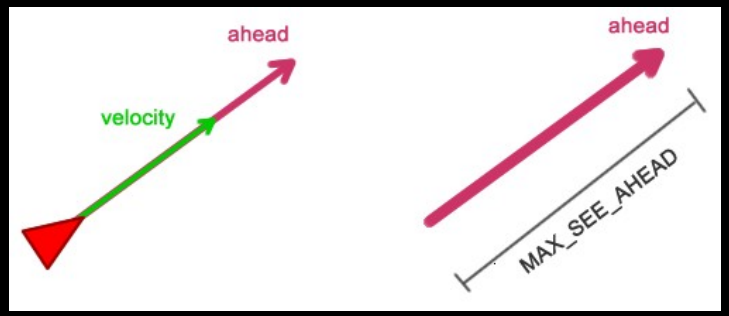
Cohesion

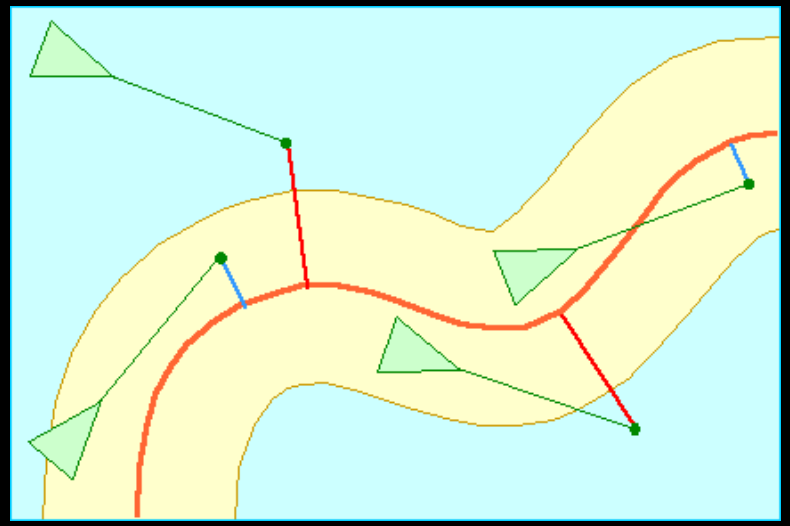
- Prefer to be at the center of the local flockmates
- Steers agent toward the center of nearby flockmates



Path Following

- Agent is steered to follow the path; we have relaxing corridor an agent is allowed to steer away from the concrete path
- Agent projects its future position **given its velocity** and then finds the nearest point of the path
- If distances between predicted point and the point on path is
  - A] smaller than the allowed distance from path => do nothing
  - B] greater => perform SEEK steering towards projected point





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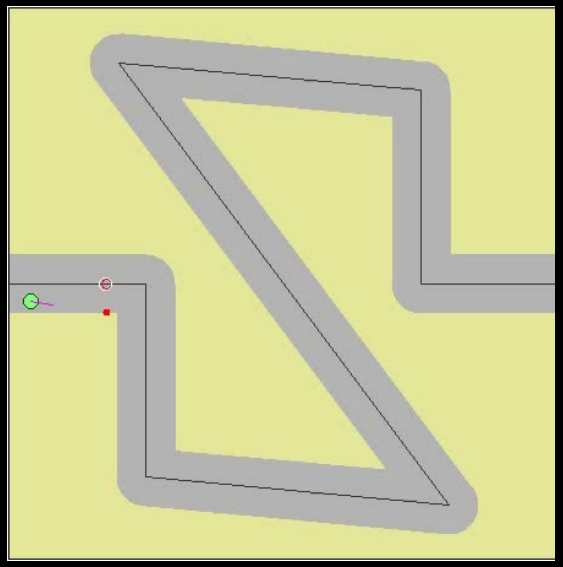

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