Artificial Intelligence for Computer Games

Local Navigation

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Moving around smoothly

https://www.red3d.com/cwr/steer/
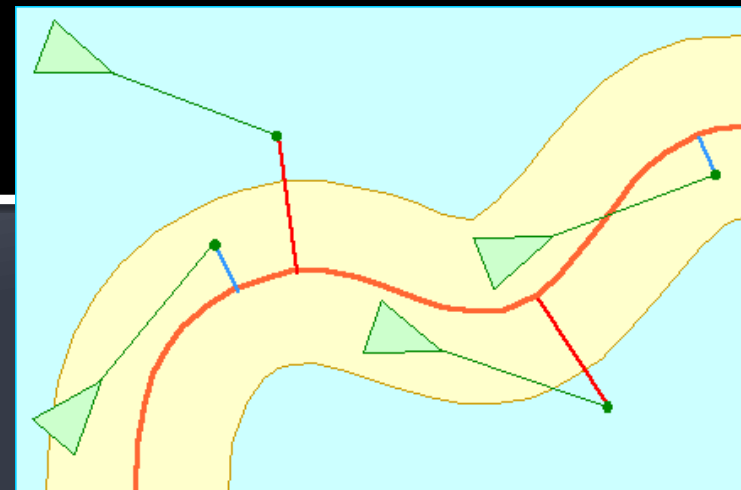
Steering Behaviors
As part of navigation
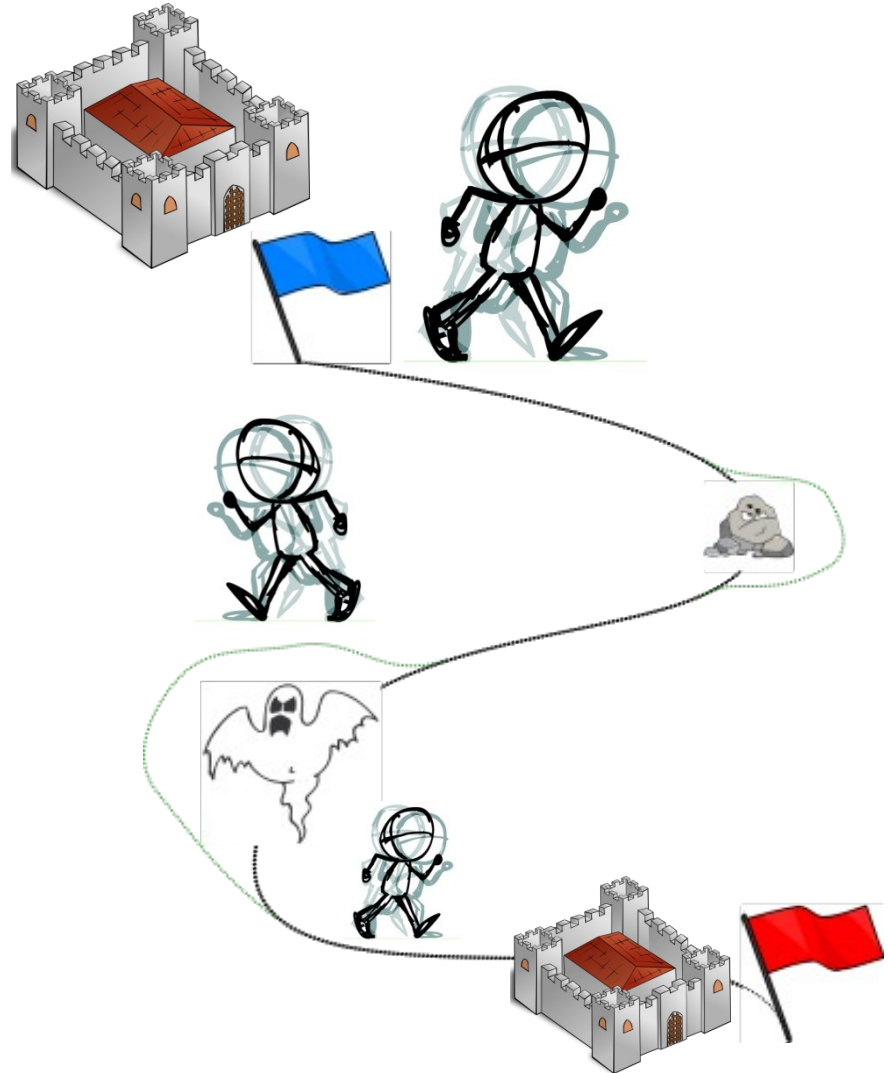
1. Action-Selection
Strategy => Goals

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 <u>forces that are adjusted every frame</u>
    - Can be easily combined
    - Computationally cheap (sum of vectors) wrt. planning
    - Produces smooth paths
    - Sometimes hard to parametrize
  - <u>Local technique</u>; does not plan, does not foresee procedurally, just projecting current velocity
    - But can be combined with path planning
  - Works per agent but <u>exhibit emergent group behaviors</u>
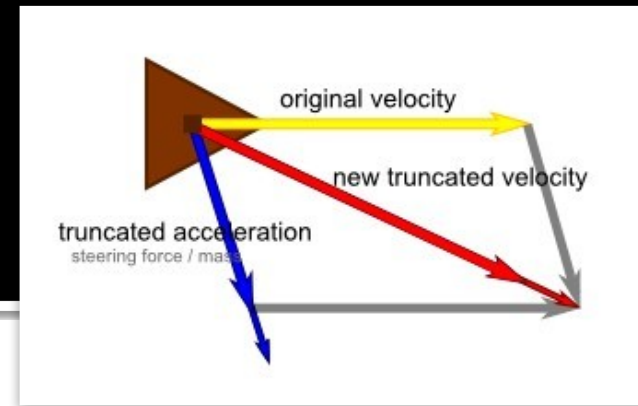
Steering Behaviors
Where do they come from?

- **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
Movement algorithm

1. **accel** = <u>**steering.calculate(args)**</u>
2. **accel** = clampLen(accel, maxAccel)
3. **velocity** = **velocity** + accel * timeDelta
4. **velocity** = clampLen(velocity, maxVelocity)
5. position += **velocity** * timeDelta
6. look-direction = **velocity**.normalized

Steering Behaviors
List of Reynold steerings

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

- A lot of 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
  - Flow Field Following

- Combined behaviors and groups:
  - Crowd Path Following
  - Leader Following
  - Unaligned Collision Avoidance
  - Queuing (at a doorway)
  - Flocking (combining: separation, alignment, cohesion)

Seek & Flee

- Seek
  - steers agent towards a <u>static</u> target
- Flee
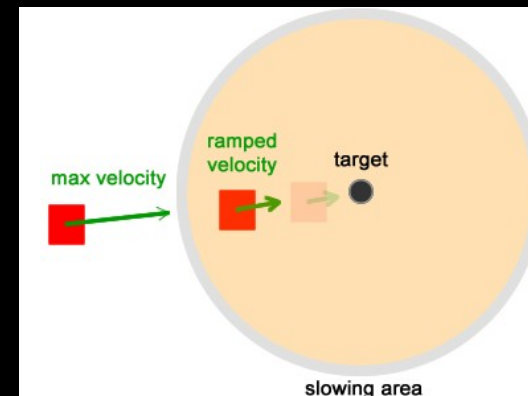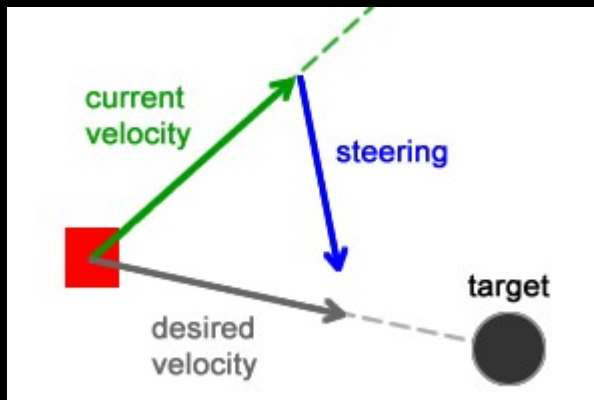 - steers agent away from a <u>static</u> target
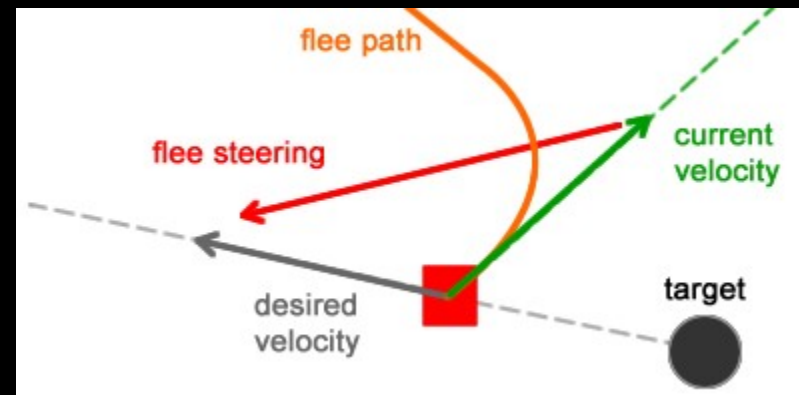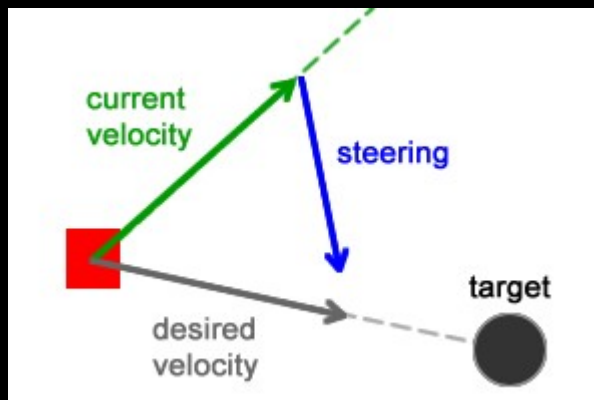
<u>Seek</u> steering force computation
```
1. to_target = target_position – my_positin
2. desired_velocity = normalize(to_target) * max_speed
3. steering = desired_velocity – velocity
```

Arrival

- As Seek, except the agent slows down as it approaches a <u>static</u> 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. steering_force = desired_velocity – velocity
```

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 next tick of the simulation
- <u>Prediction based on distance & target velocity</u>
  - Nearer the target is, less the prediction (T) is used
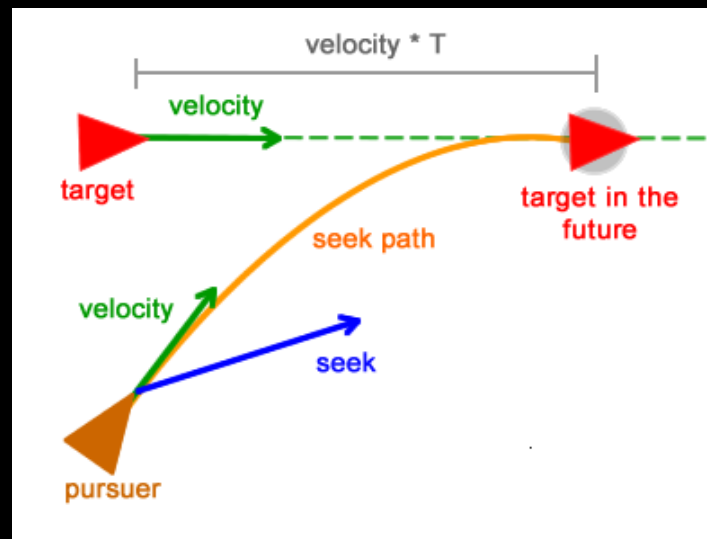
Wander

- 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
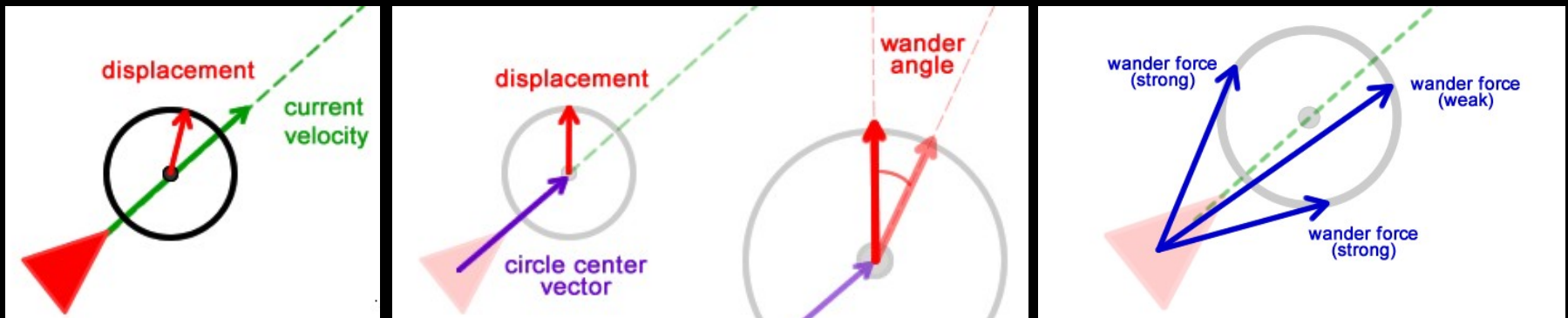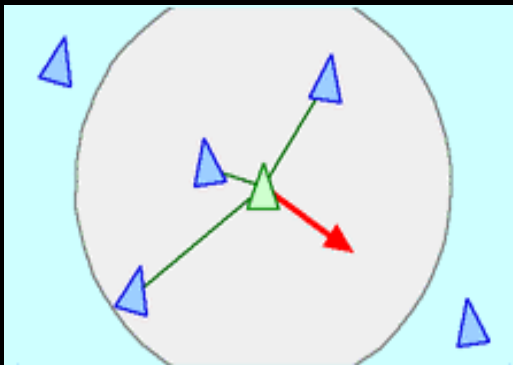
Steering Behavio**r**
Inspiration

Flocking Model of Boids
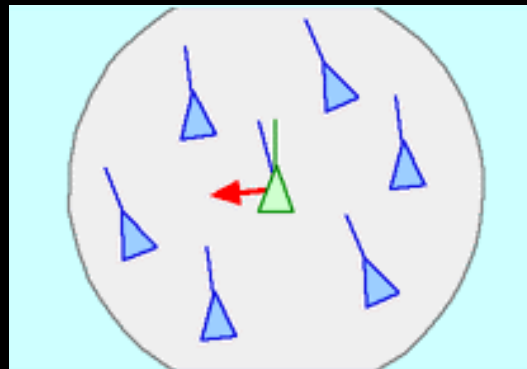
- Bird like object (Boid); 3 steering rules

Separation

- Do not get too close to nearby flockmates

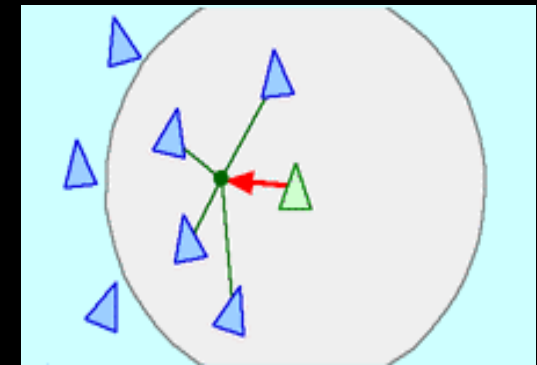- Steers boid from too close flockmates

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
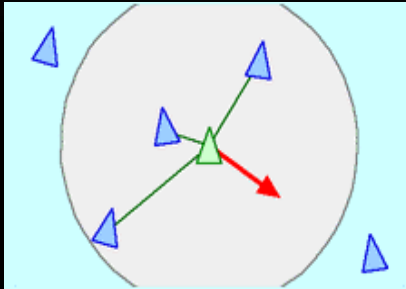
Cohesion

- Prefer to be at the center of the local flockmates

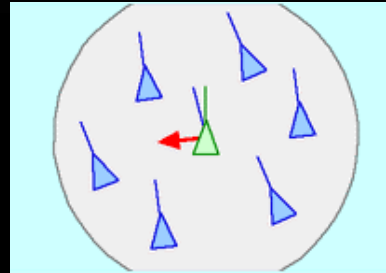- Steers agent to the center of nearby flockmates
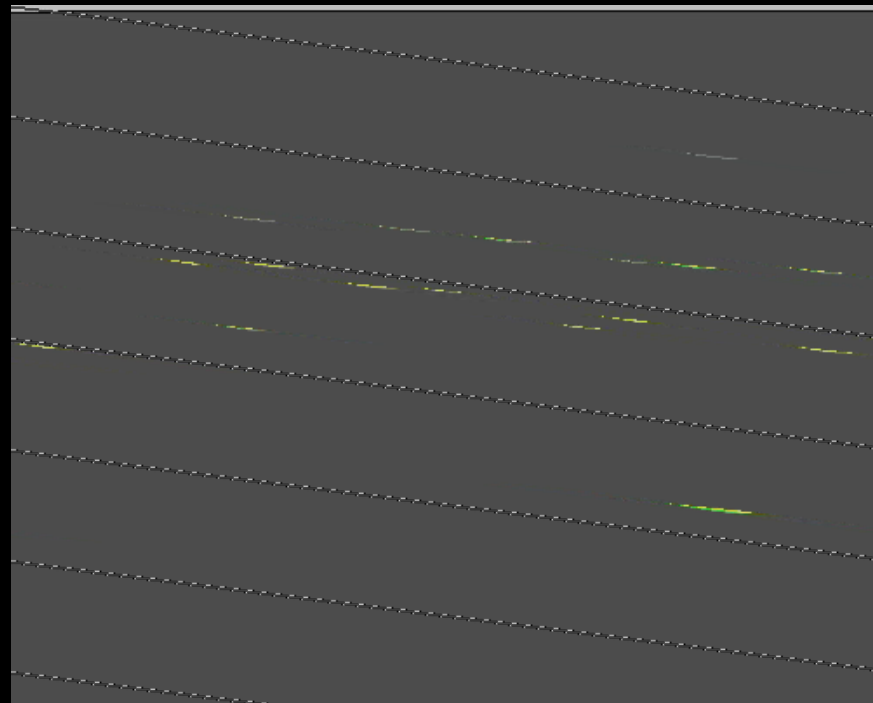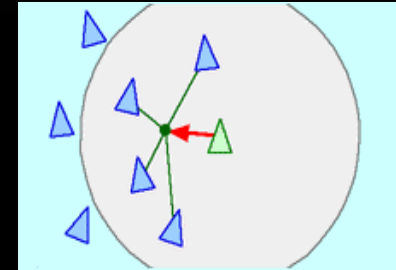
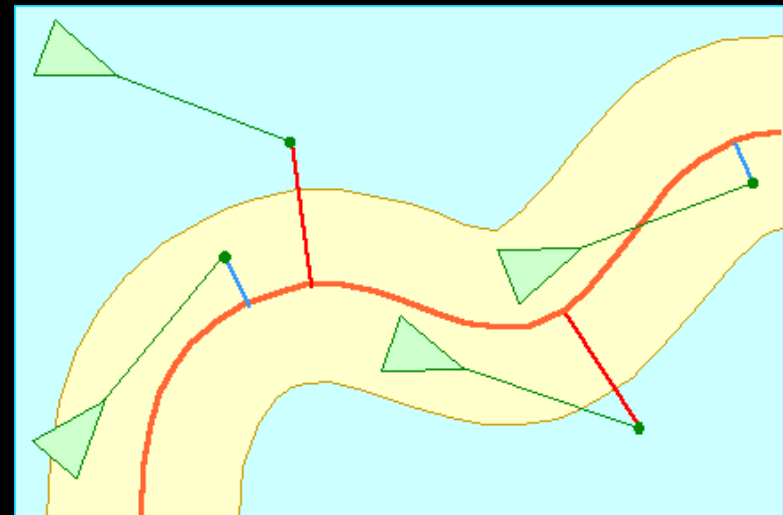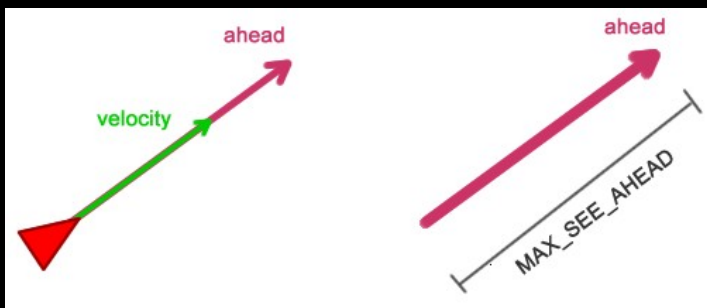# Flocking Model of Boids

Separation

Alignment

Cohesion

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

Path Following

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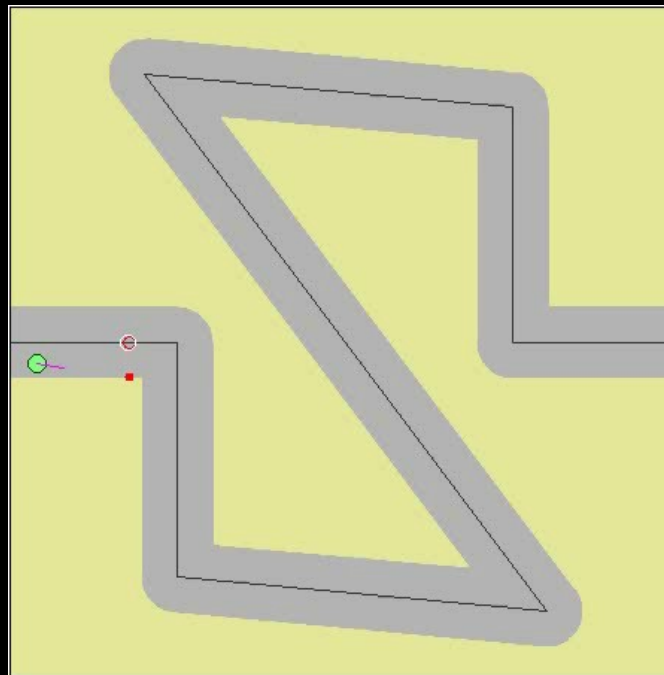
EVROPSKÁ UNIE
Evropské strukturální a investiční fondy
Operační program Výzkum, vývoj a vzdělávání

MINISTERSTVO ŠKOLSTVÍ,
MLÁDEŽE A TĚLOVÝCHOVY