Physics-based Racing AI

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MILESTONE


SBK X
SUPERBIKE WORLD CHAMPIONSHIP


SUPERSTARS
NEXT CHALLENGE
V8

Overview

- **Part 1 – Racing AI Tutorial**
  - **Basics in Steering, Throttle & Brake managment**
  - **Group behaviours (avoiding, overtakes)**

- **Part 2 – A method for optimizing AI performances**
  - **Fairness in racing games**
  - **Main alghoritm for an AI optimizator**

Part 1

RACING AI TUTORIAL

AI - Physics interface

AI

Input: Steer, Throttle, Brake, ...

Physics

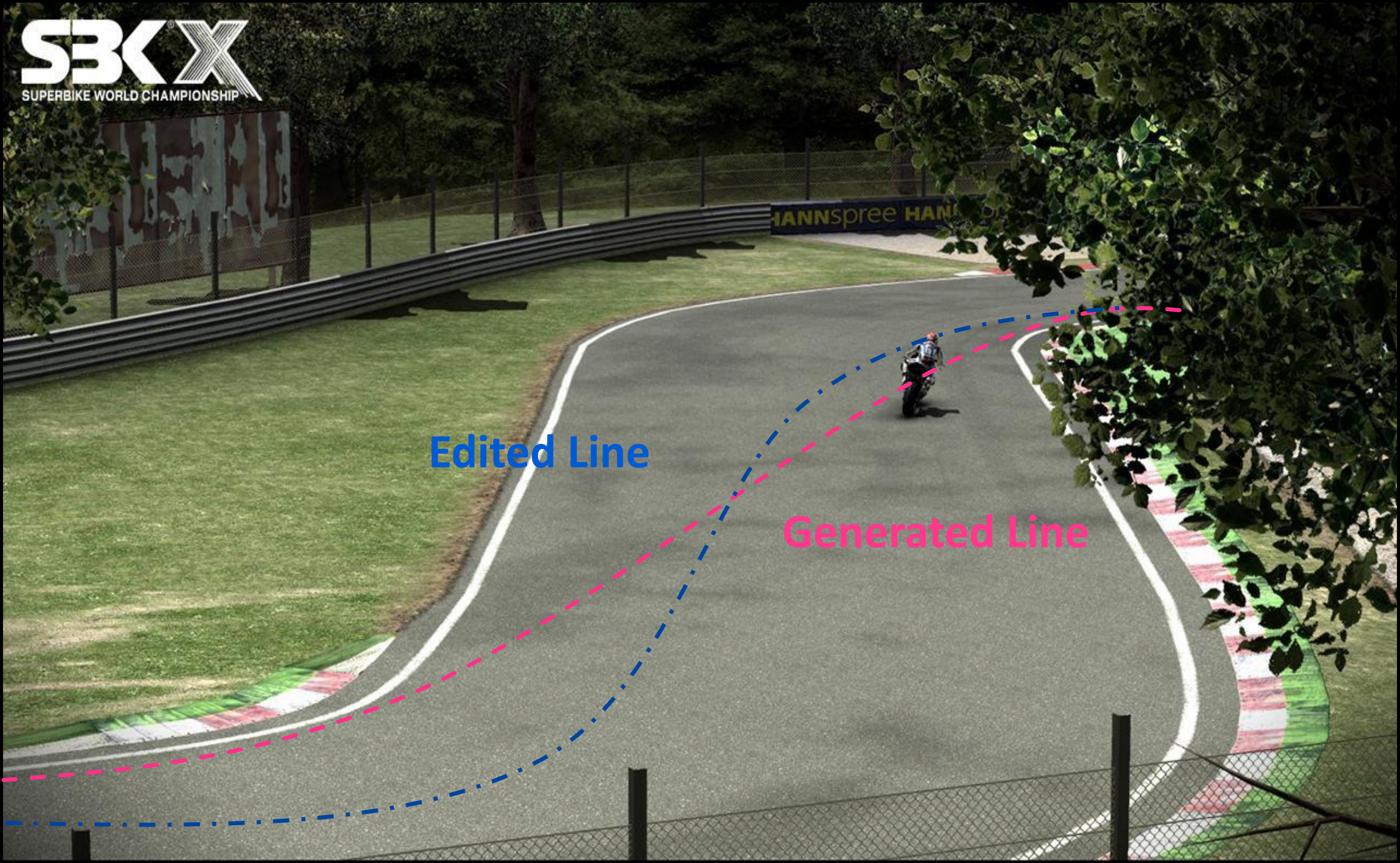
Position, Direction, Speed, ...

Position

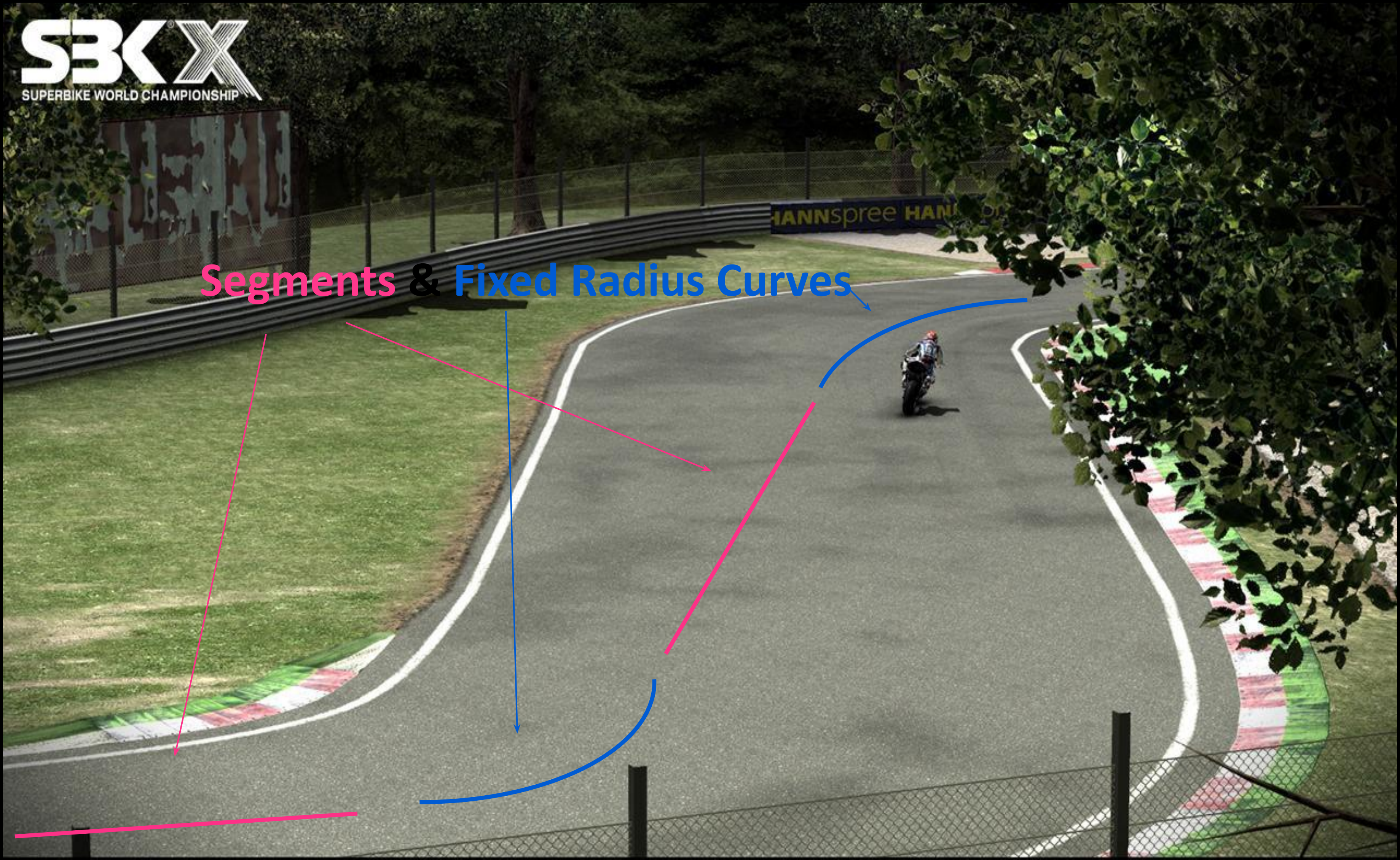
AI - Physics interface

- Physics as a black box (too much complexity to forecast exactly the results of an action)
- Physics changes during the project

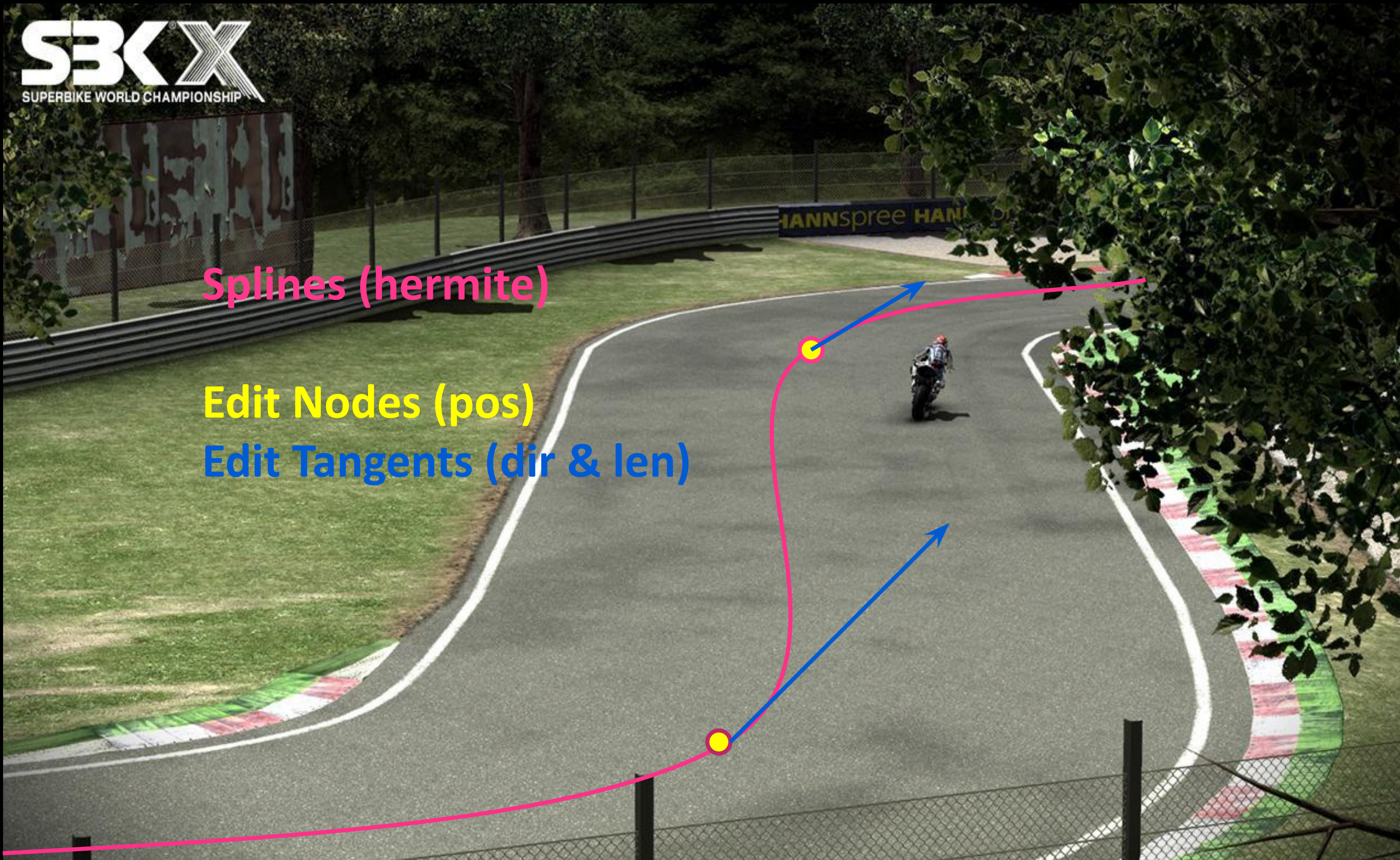
Racing Line


SBK X
SUPERBIKE WORLD CHAMPIONSHIP
HANNspree
Edited Line
Generated Line

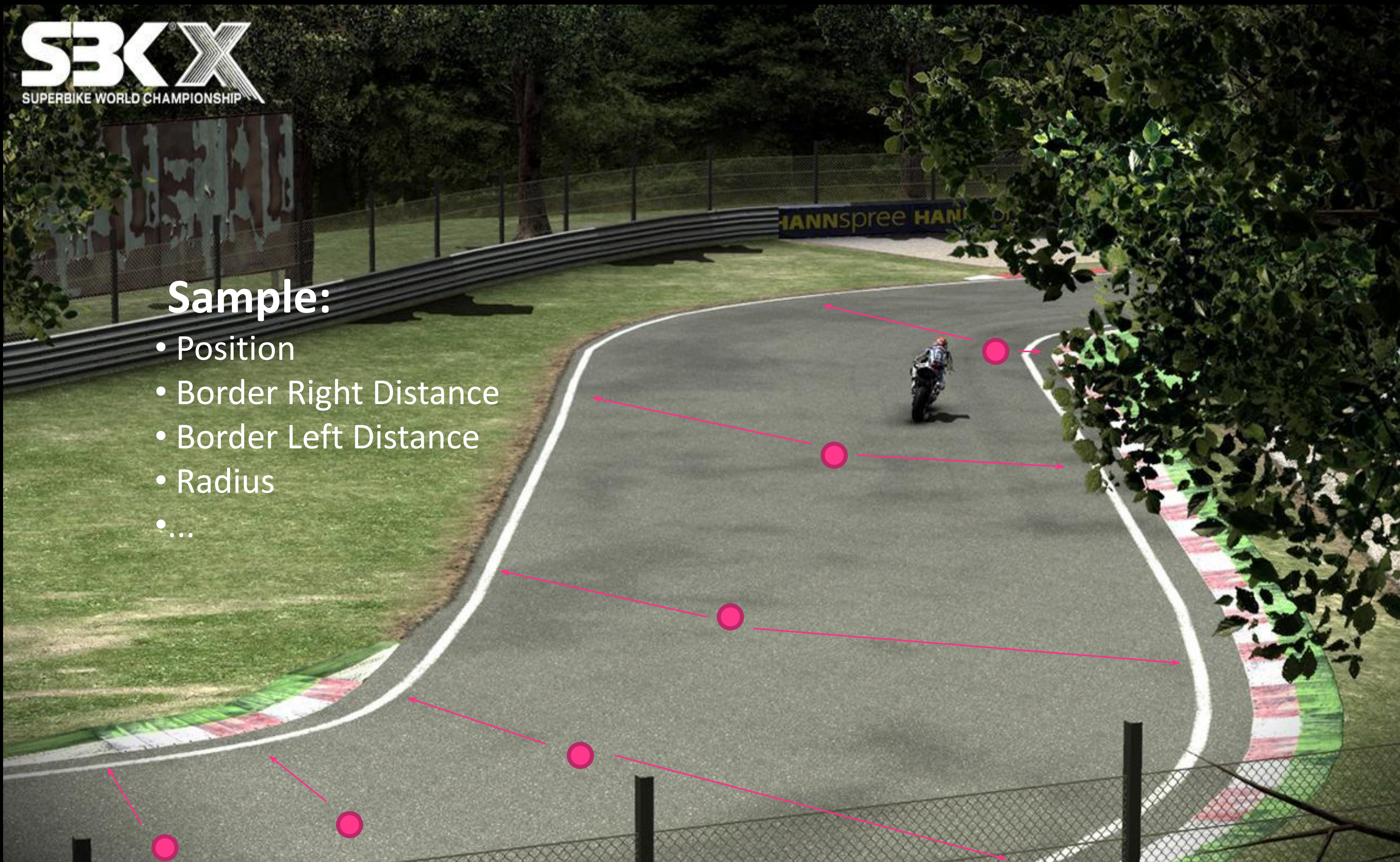
Representation



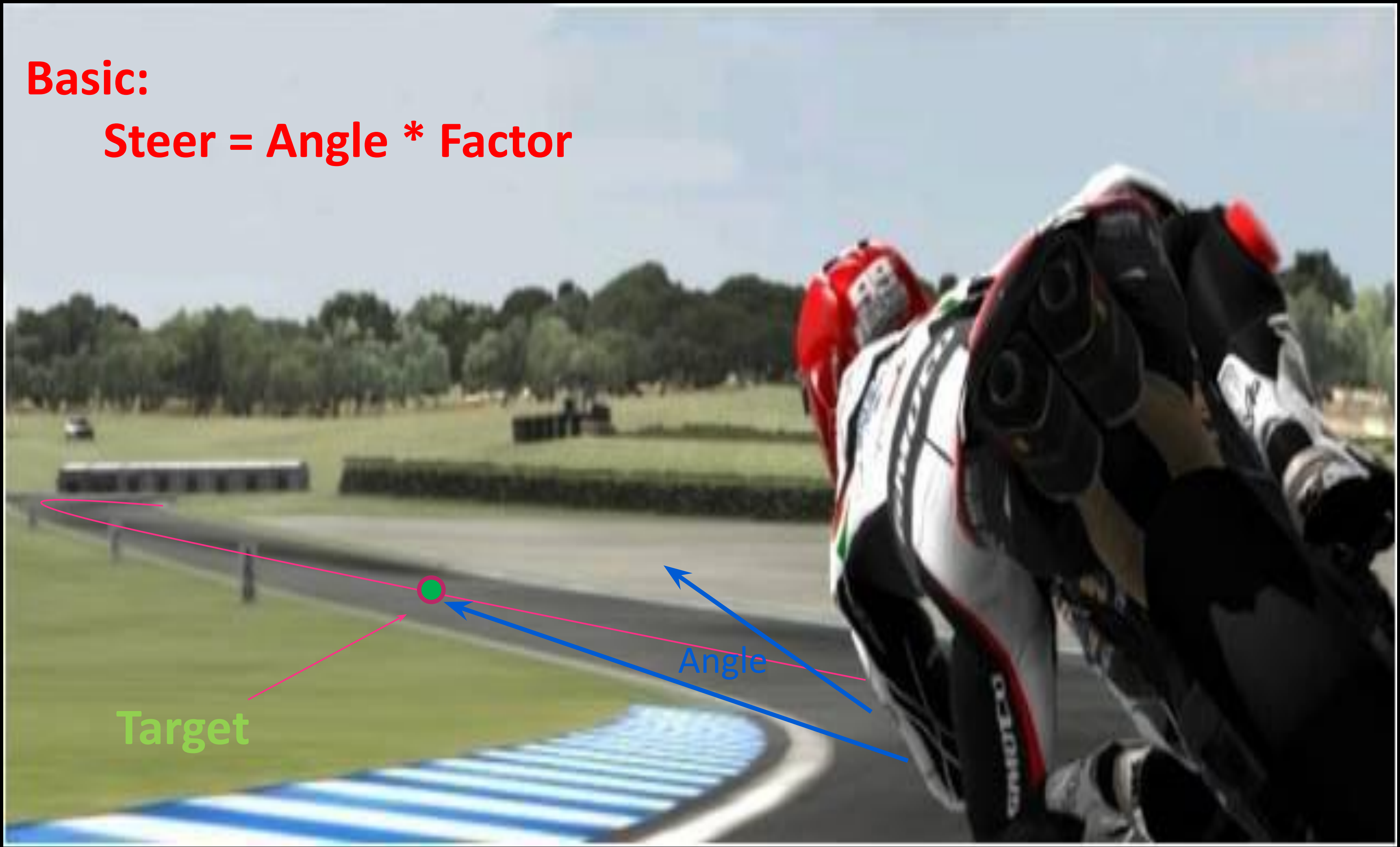
Representation



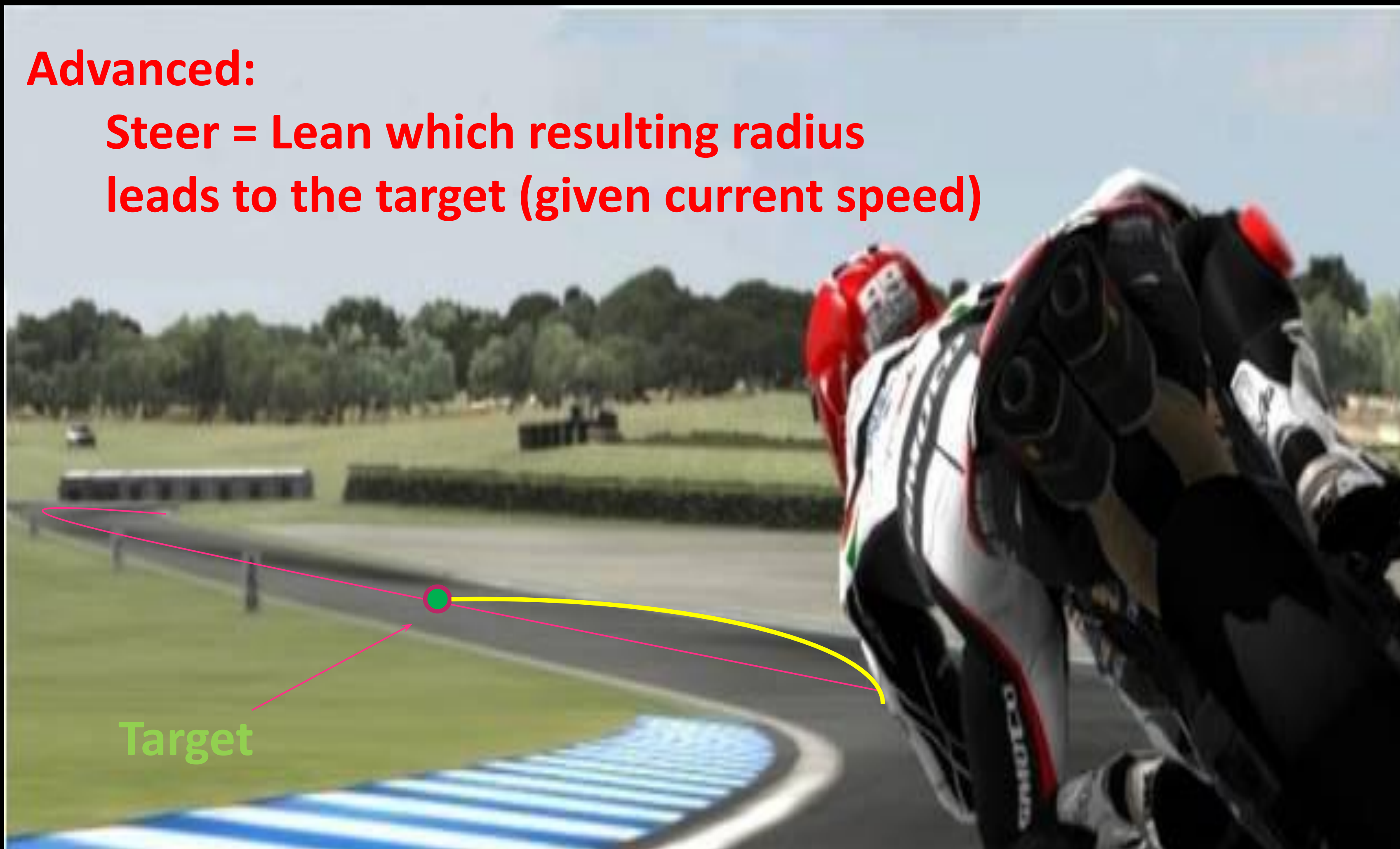
Sampling the racing line



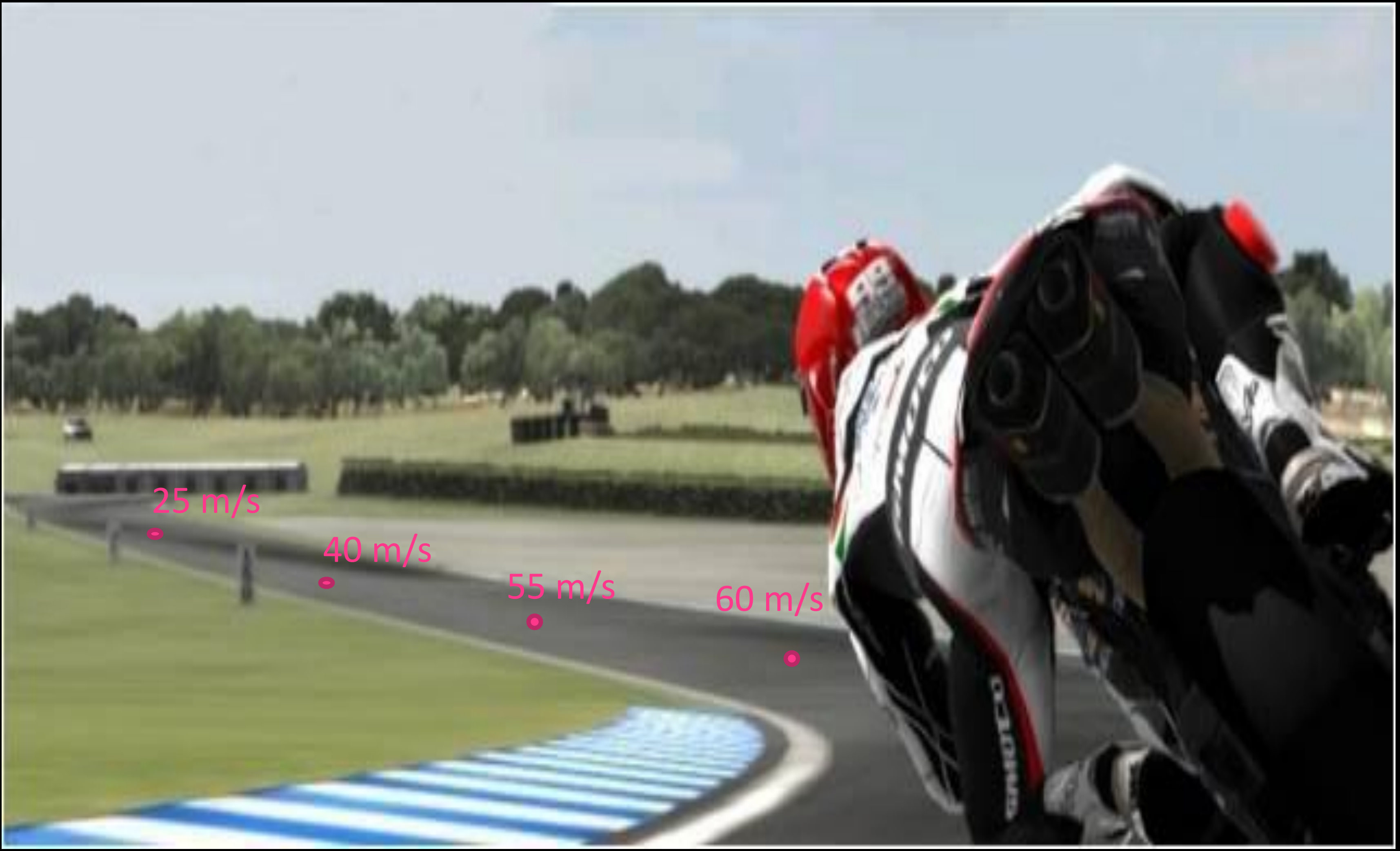
Following the racing line



Following the racing line



Throttle and Brake managment



Throttle and Brake managment

- Basic implementation:
  - Speed < Speed Target ? Throttle = MAX
  - Speed > Speed Target ? Brake = MAX

- Better implementation uses Throttle and Brake modulation (could model also driver characteristics, like aggressiveness or smoothness in driving)

Recovery Mechanics

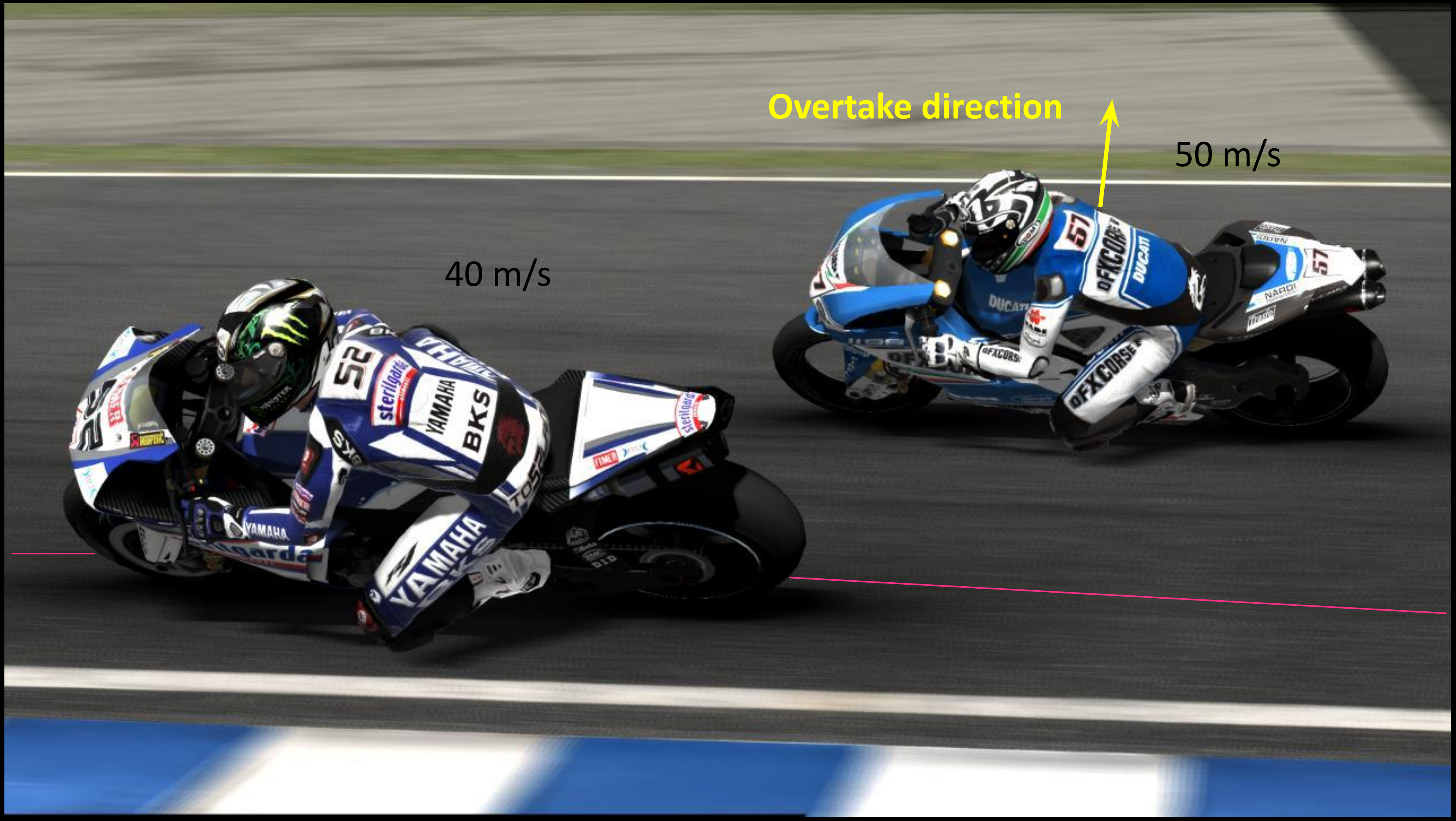
- **Mechanics that detect a dangerous situation and apply an action to restore a safer situation**
  - **AI that detect too much dritfing uses counter steer (car)**
  - **AI that detect a big angle with the target uses a rear brake (bike)**

- **Drawback: loss of performances**

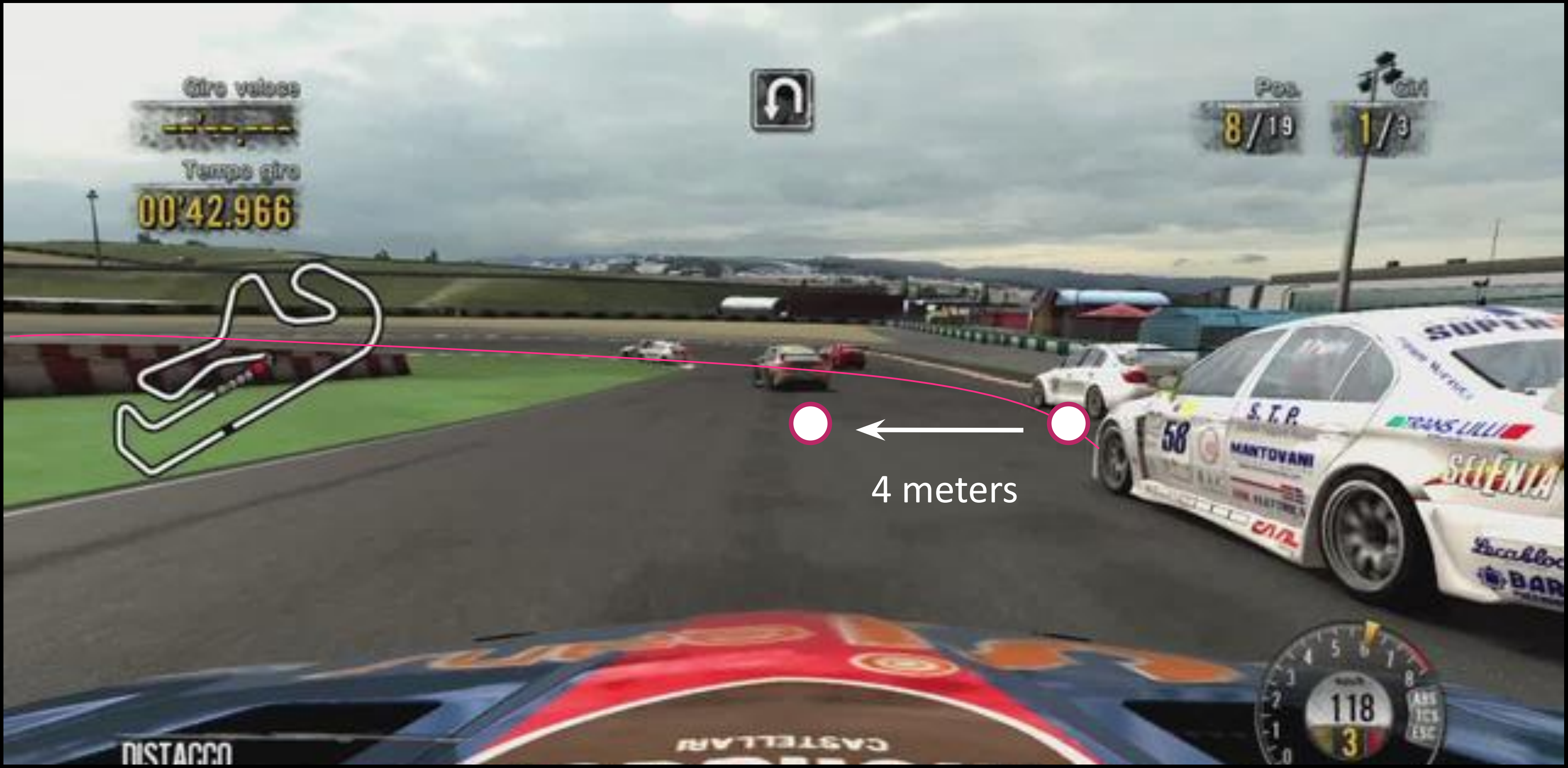
Avoiding

Avoiding

Overtake



Overtake



Giro veloce
Tempo giro
00'42.966
Pos.
8/19
Giri
1/3
4 meters
118
3
DISTACCO

Overtake

- Adding component to steer (Steer = SteerToTarget + C)
  - Fast reaction
  - Can increase/decrease dynamically the component
  - Harder to control distances and deviating speed

- Considering more vehicles
  - Calculating the overall occlusion
  - Finding the nearest free block

Mistakes

- “Natural” errors
  - Collisions
  - Losing control in overtake/group situations

- Generated errors
  - Steering, Throttle, Brake
  - Falls (bike): low side, high side

Car AI


Fastest Lap
Lap Time
00'09.950
Pos
Laps
19/19
1/5
Yellow Flag: 0
Blue Flag: 0
BW2 Flag: 0
Last Perc (Debug): 0.00
Last Perc Time (Debug): 0.00
Last Dist (Debug): 0.00
Black Flag: 0
Checkers Flag: 0
Material Id: 0
Black Flag Count Down: 4.00

Bike AI


19-21
Current
00'41.20
Laps
1-4
Sykes T.
Right Dist: 12.32
Left Dist: 2.88
Average Distance: 1.25
Error: 1.00
Yellow Flag: 0
OVERTAKE
1 3 Biaggi M.
2 84 Fabrizio M.
LIMBOX OFF
Autodrive

Part 2

A METHOD FOR OPTIMIZING AI PERFORMANCES

Fairness in racing games

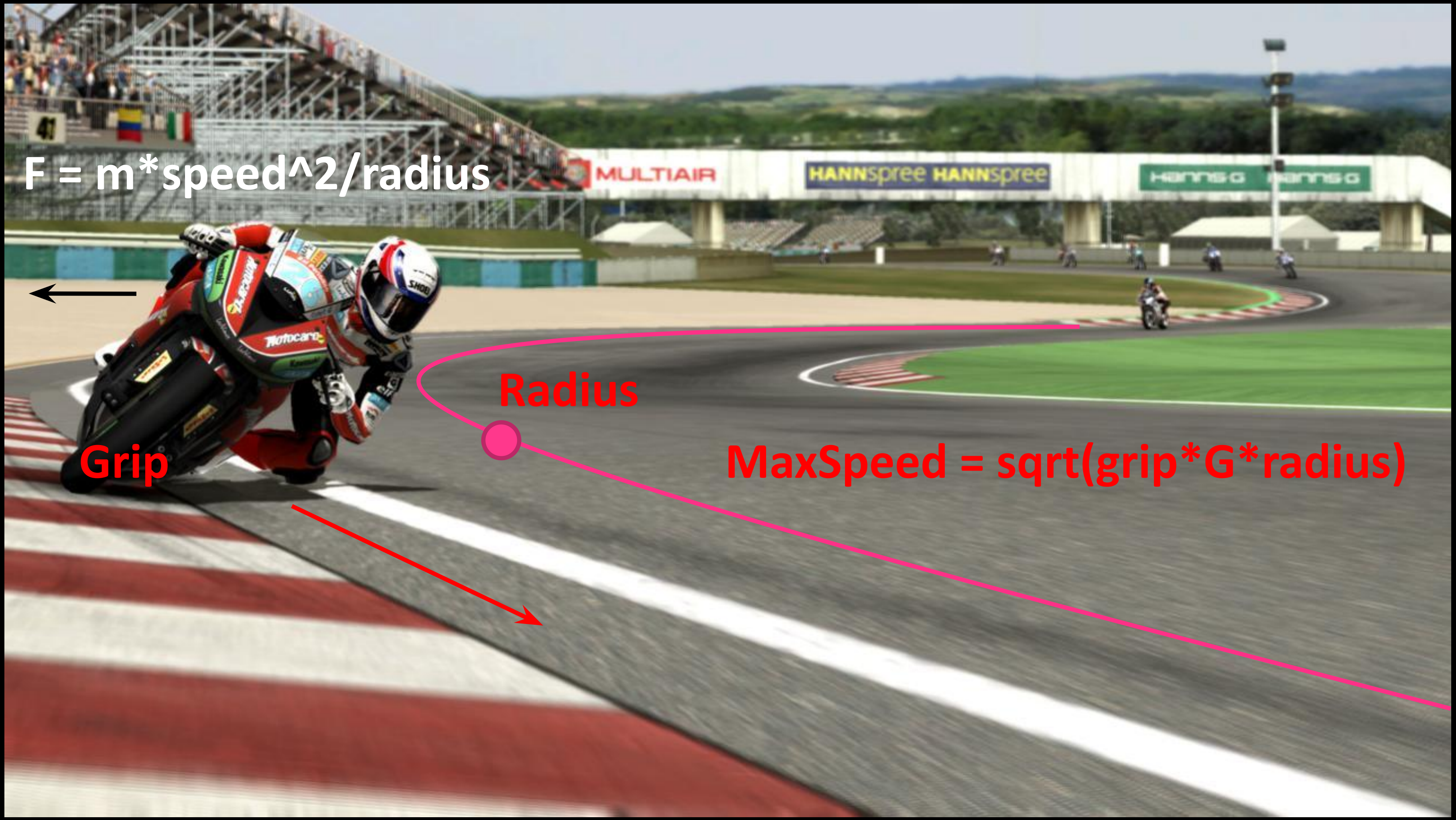
- Common trick is using simplified (or helped) physics for Ais
  - Easier to obtain good performances (and tune)
  - Easier managing group situations
  - Visual effect not too realistic
  - Difficult to maintain a fair situation with the player

Fairness in racing games

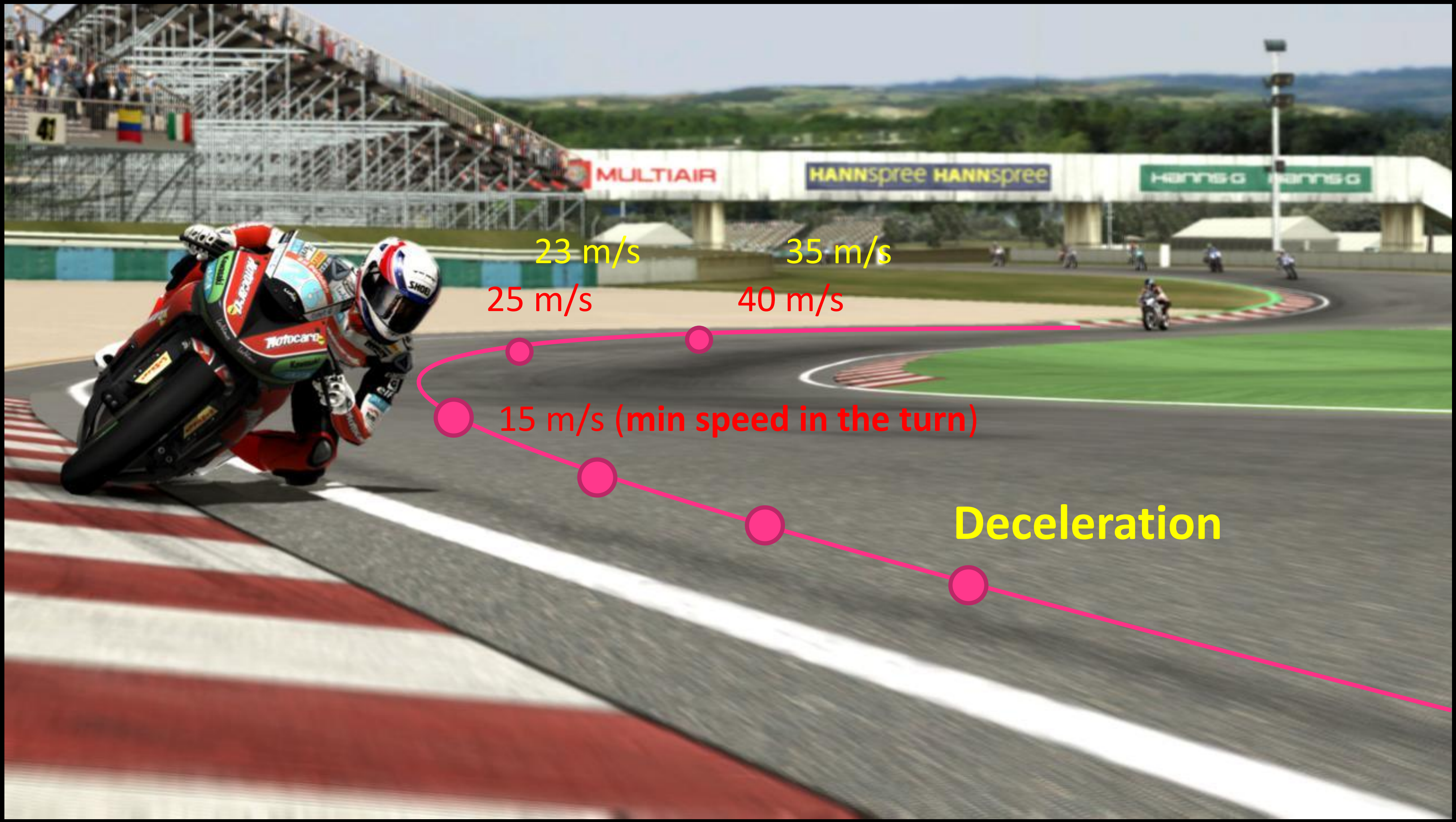
- Using (almost) the same player physics
  - Much better under a visual point of view (realism)
  - AI can't do something that player can't so fairness is guaranteed
  - Much more difficult to obtain good performances
  - More difficult also managing group situations

- Need a better method than simple speed precalculation

Speed precalculation



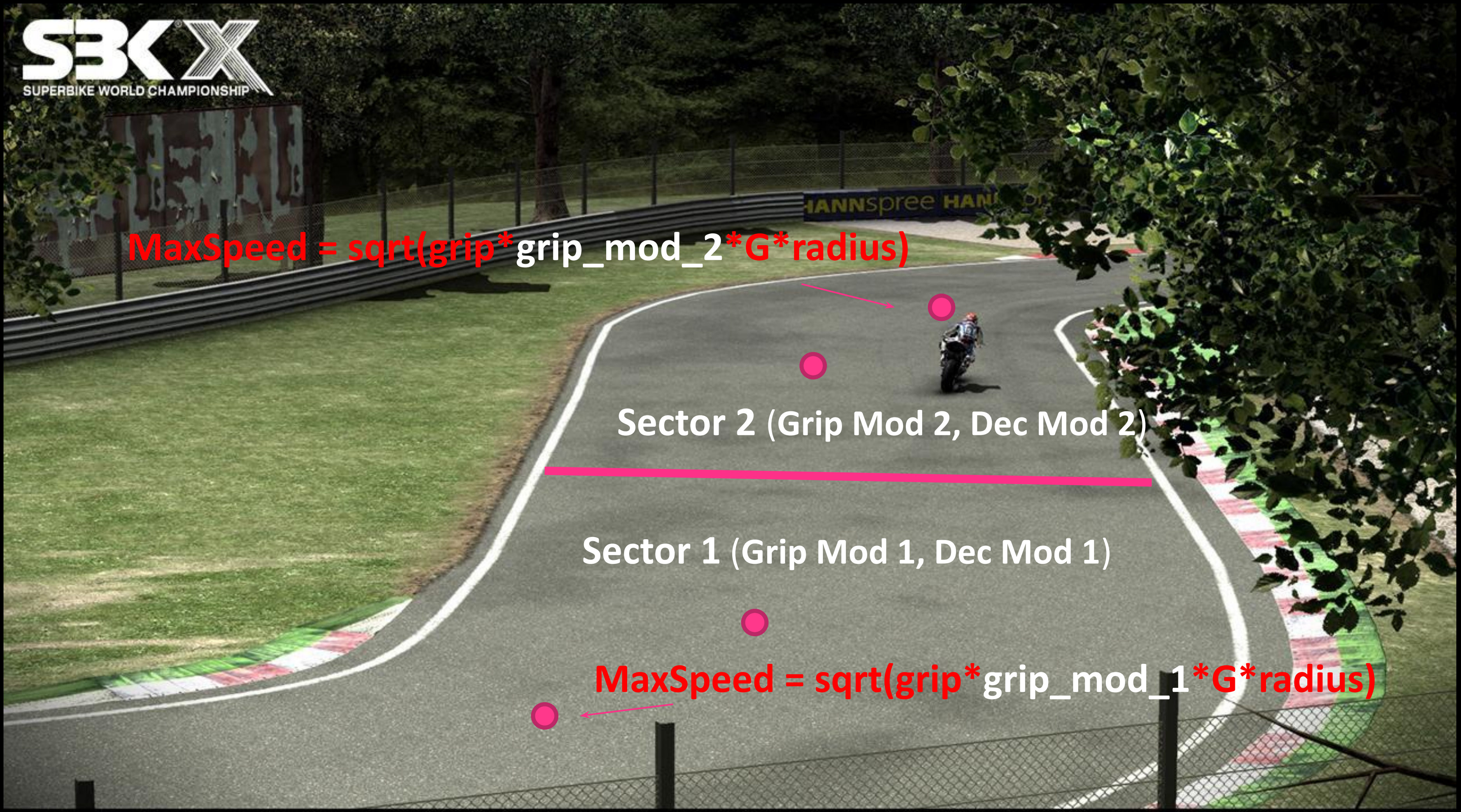
Speed precalculation



Speed precalculation

- You can tweak the precalculation affecting the grip and deceleration values the alghoritm consider (not the real grip and brakes)
- Solution would never be optimal (improve in some points but exit from the track in others, or stay into the track but still too slow in some sectors)

Dividing into sectors



Iterative method

- **Detect sectors in an automatic way**
  - **Start when inverse radius != 0, end when inverse radius returns 0**
- **Make the AI drive (graphics disabled)**
- **Act on grip and deceleration modifier**
  - **Define a step**
  - **Increase grip modifier for higher speeds**
  - **Increase deceleration modifier for more aggressive approach**

Iterative method

- Increment modifiers as soon as lap time decrease
- One lap could not be sufficient (starting conditions). Up to 5 laps for evaluation.
- Pass to an other sector when lap time does not decrease any more
- First pass on grip modifiers, second pass on decelerations
- More iteractions could help (restart the process)

Extra conditions

- Considering only lap time is often not sufficient
- Need extra conditions to be satisfied
  - Out of track check
  - Distance from ideal line
  - Others (skid, wobble, wheelie, …)
- Invalidate single lap or the entire trial when a condition is not satisfied

Resulting Data

- Stored as a track asset
  - For each sector: start sector info, end sector info, grip modifier, deceleration modifier

- Speeds are calculated at initialization time taking in account generated modifiers
  - Flexibility in case of ideal line or grip changes

Not optimized lap

Grip modifiers

BestTime = 128.11
Grip Modifier 0 = 1.00
BestTime = 127.76
BestTime = 127.45
BestTime = 127.21
BestTime = 127.10
Grip Modifier 1 = 1.40
BestTime = 126.93
BestTime = 126.80
BestTime = 126.70
BestTime = 126.63
Grip Modifier 2 = 1.40
...

Deceleration modifiers

BestTime = 114.59

Dec Modifier 0 = 1.00

BestTime = 114.51

BestTime = 114.38

BestTime = 114.28

BestTime = 114.23

BestTime = 114.19

Dec Modifier 1 = 1.50

BestTime = 114.18

Dec Modifier 2 = 1.10

Dec Modifier 3 = 1.00

Dec Modifier 4 = 1.00

...

Optimized lap (no extra conditions)

Adding extra conditions

- Example
  - No out of track
  - Ideal line distance < 3 meters (CM of vehicle)

Optimized lap (with extra conditions)

Advantages

- Simple implementation
- Editable results
- Speeds are still proportional to the radius
- Can tweak by affecting the (real) grip (but not too much)

Possible improvements

- Step managment
- Order optimization
- Extra conditions
- Acting not only on speeds (driving parameters)

Conclusions

- Fairness is very important
- Difficult to forecast physics (and track)
- Trying and see what happen is a good solution

Thanks!

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