



Physics-based Racing AI

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Overview

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

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

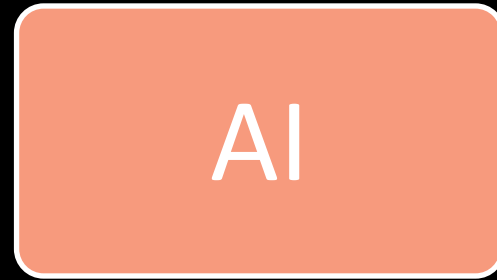


Part 1

RACING AI TUTORIAL

Game AI Conference, Paris June 2010

AI - Physics interface



Input: Steer, Throttle, Brake, ...



Position, Direction, Speed, ...

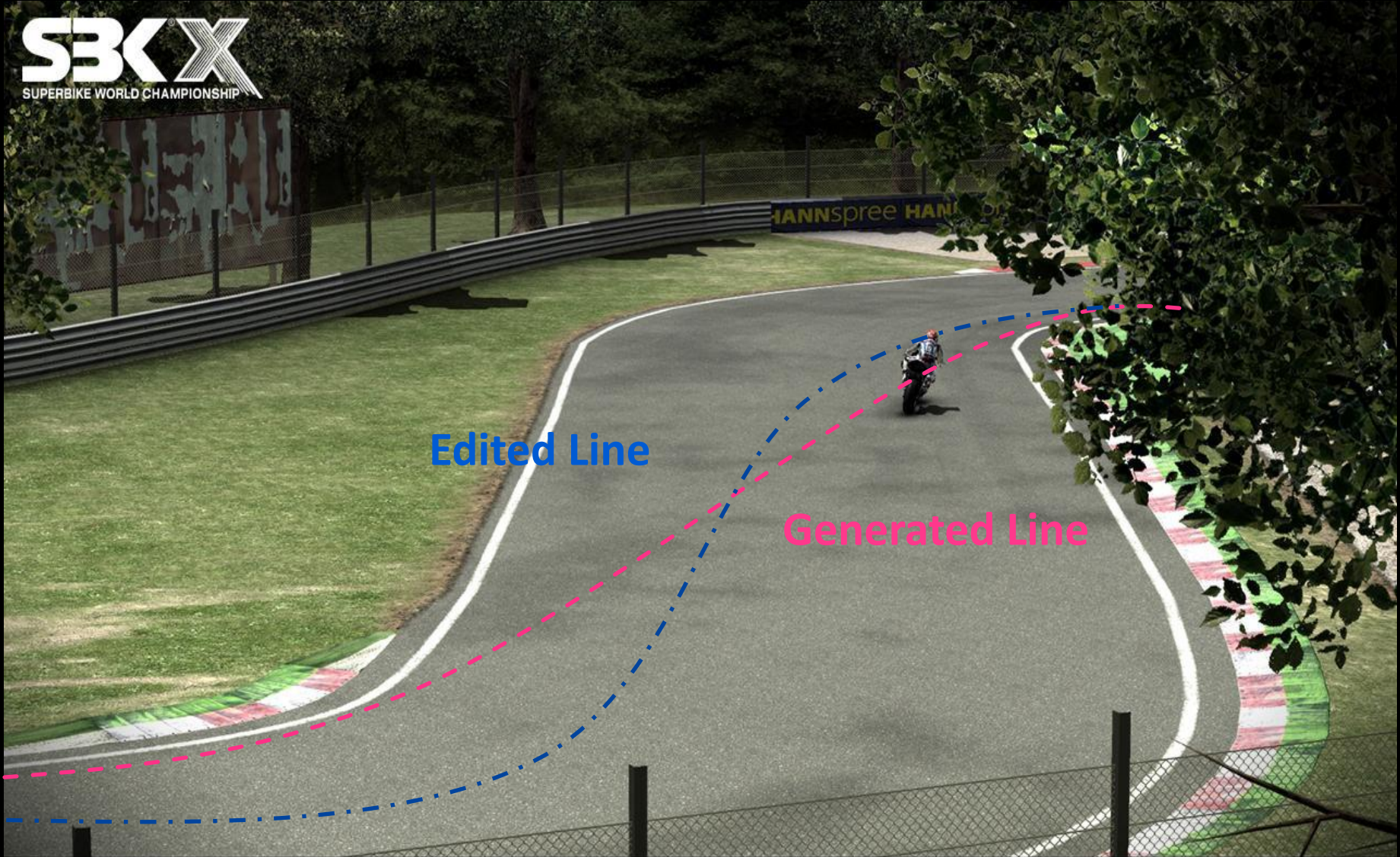




AI - Physics interface

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

Racing Line

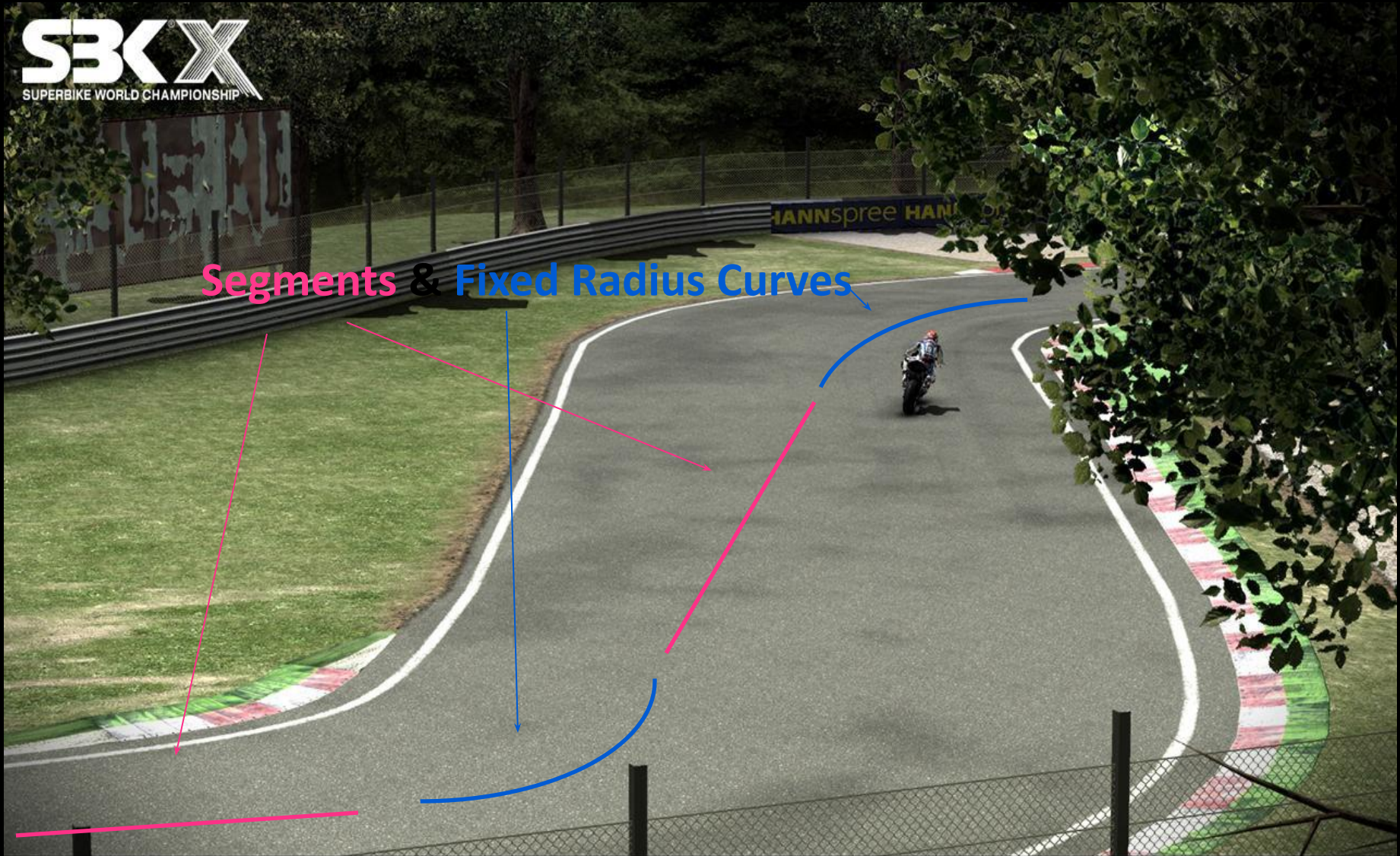


SBKX
SUPERBIKE WORLD CHAMPIONSHIP

Edited Line

Generated Line

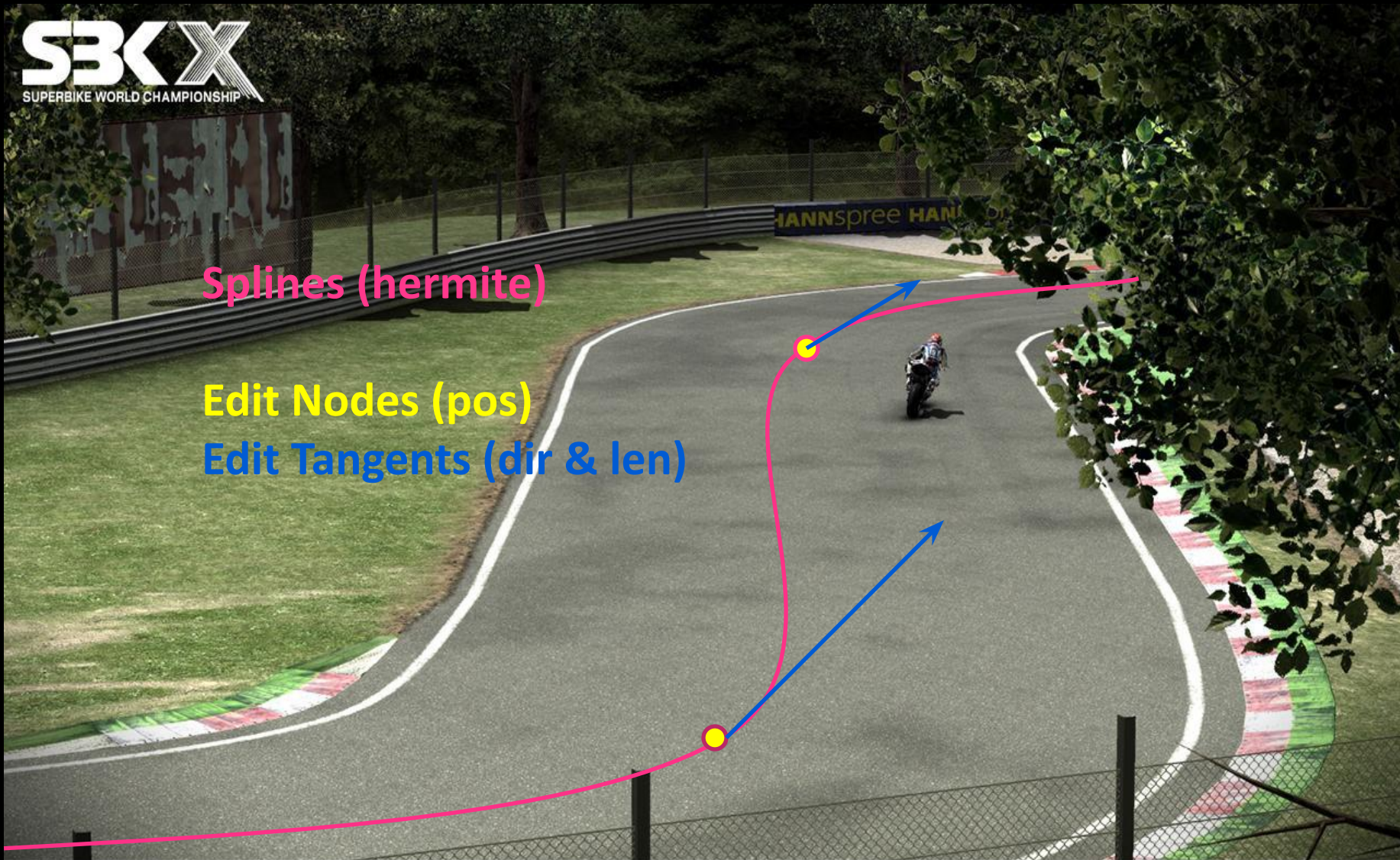
Representation



SBKX
SUPERBIKE WORLD CHAMPIONSHIP

Segments & Fixed Radius Curves

Representation



SBKX
SUPERBIKE WORLD CHAMPIONSHIP

Splines (hermite)

Edit Nodes (pos)

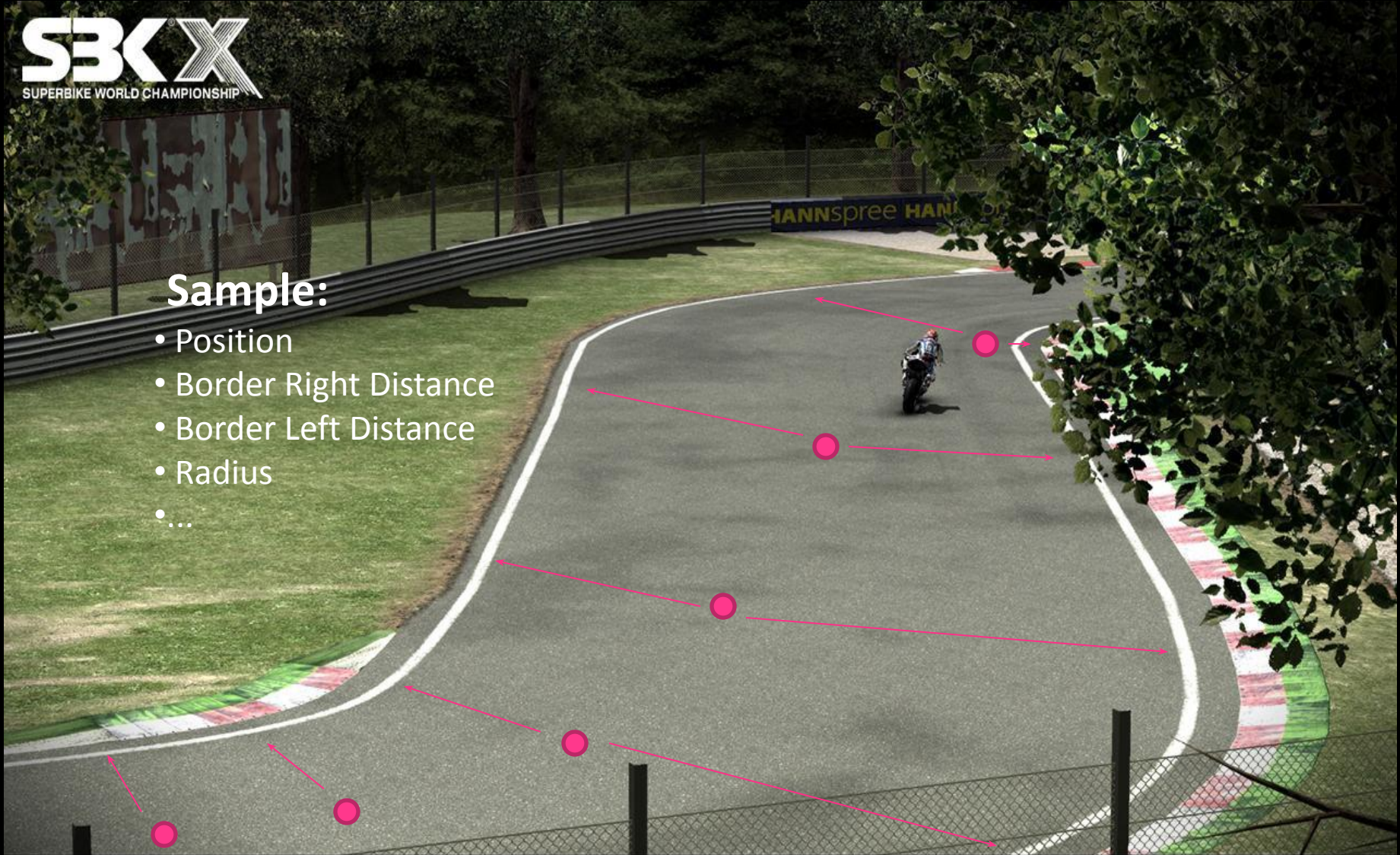
Edit Tangents (dir & len)

Sampling the racing line



Sample:

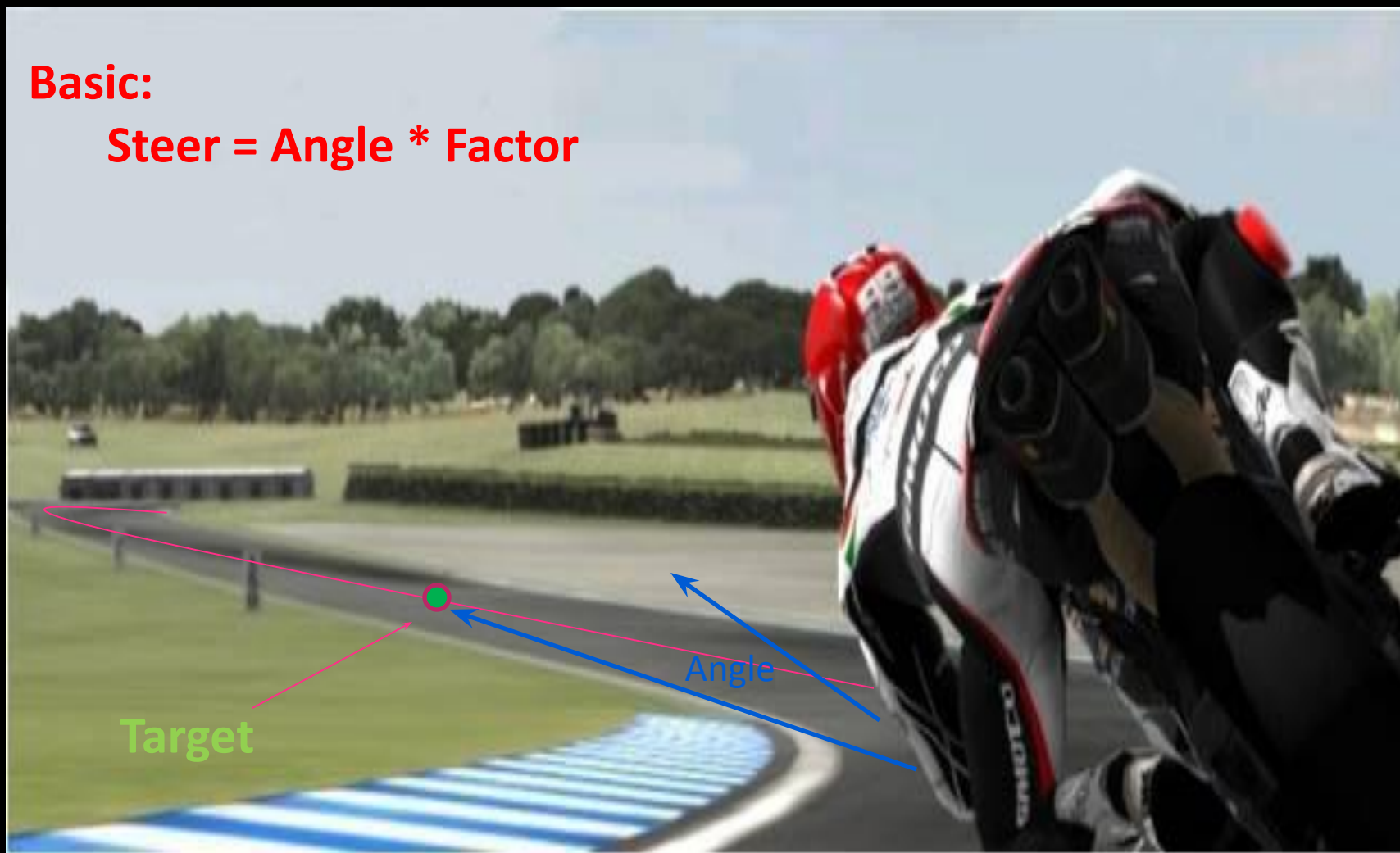
- Position
- Border Right Distance
- Border Left Distance
- Radius
- ...



Following the racing line

Basic:

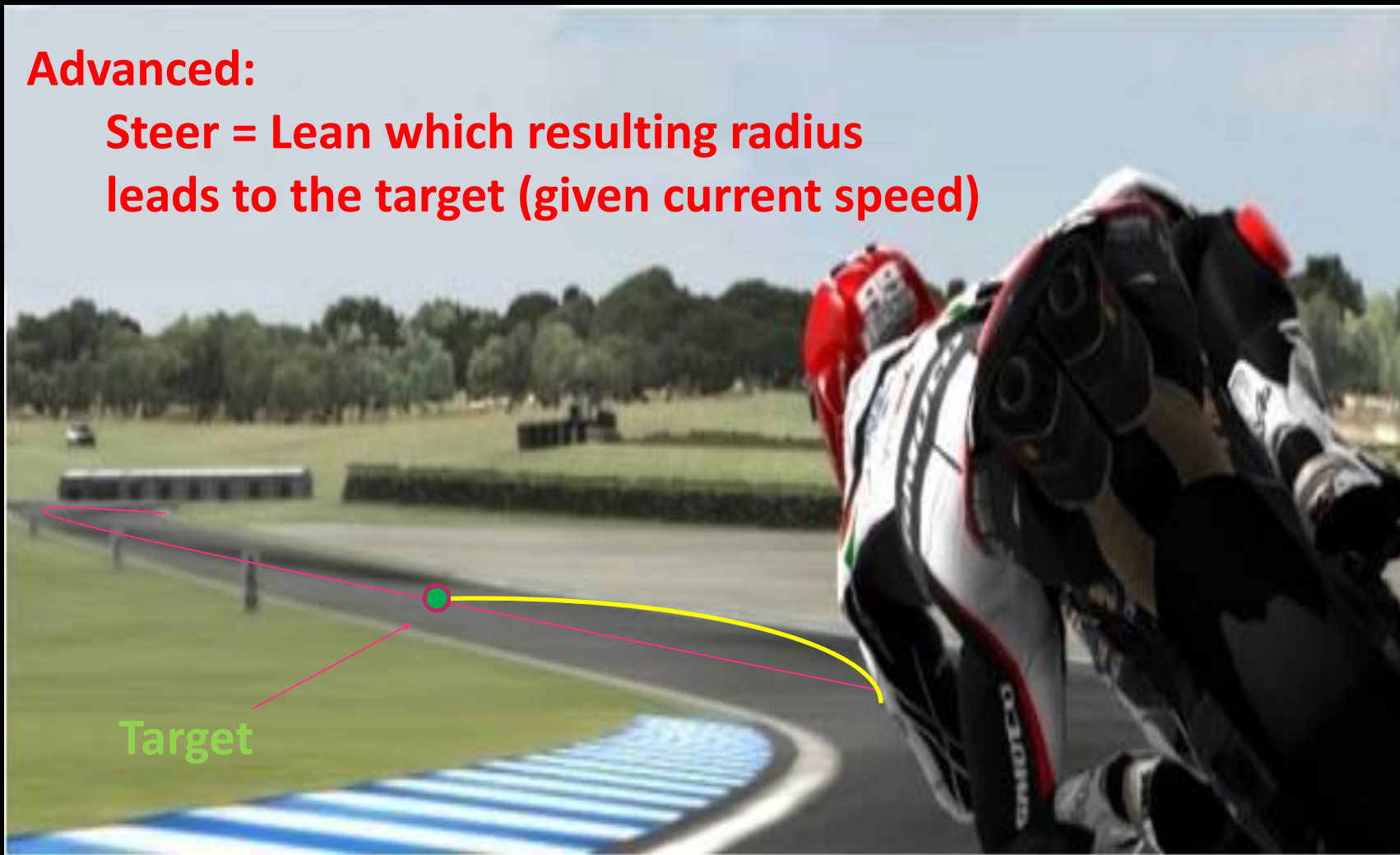
$$\text{Steer} = \text{Angle} * \text{Factor}$$



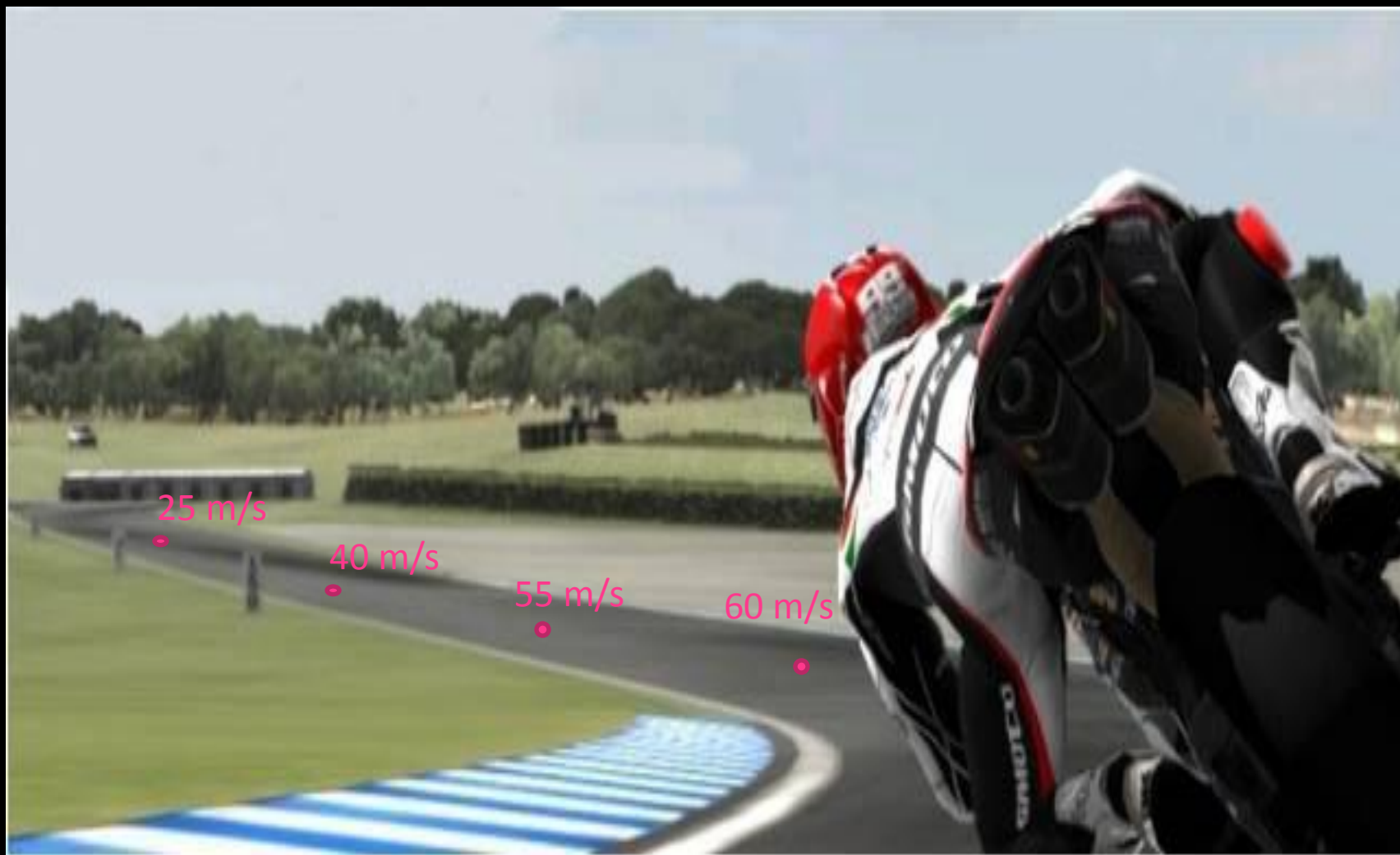
Following the racing line

Advanced:

Steer = Lean which resulting radius leads to the target (given current speed)



Throttle and Brake management





Throttle and Brake management

- **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)**



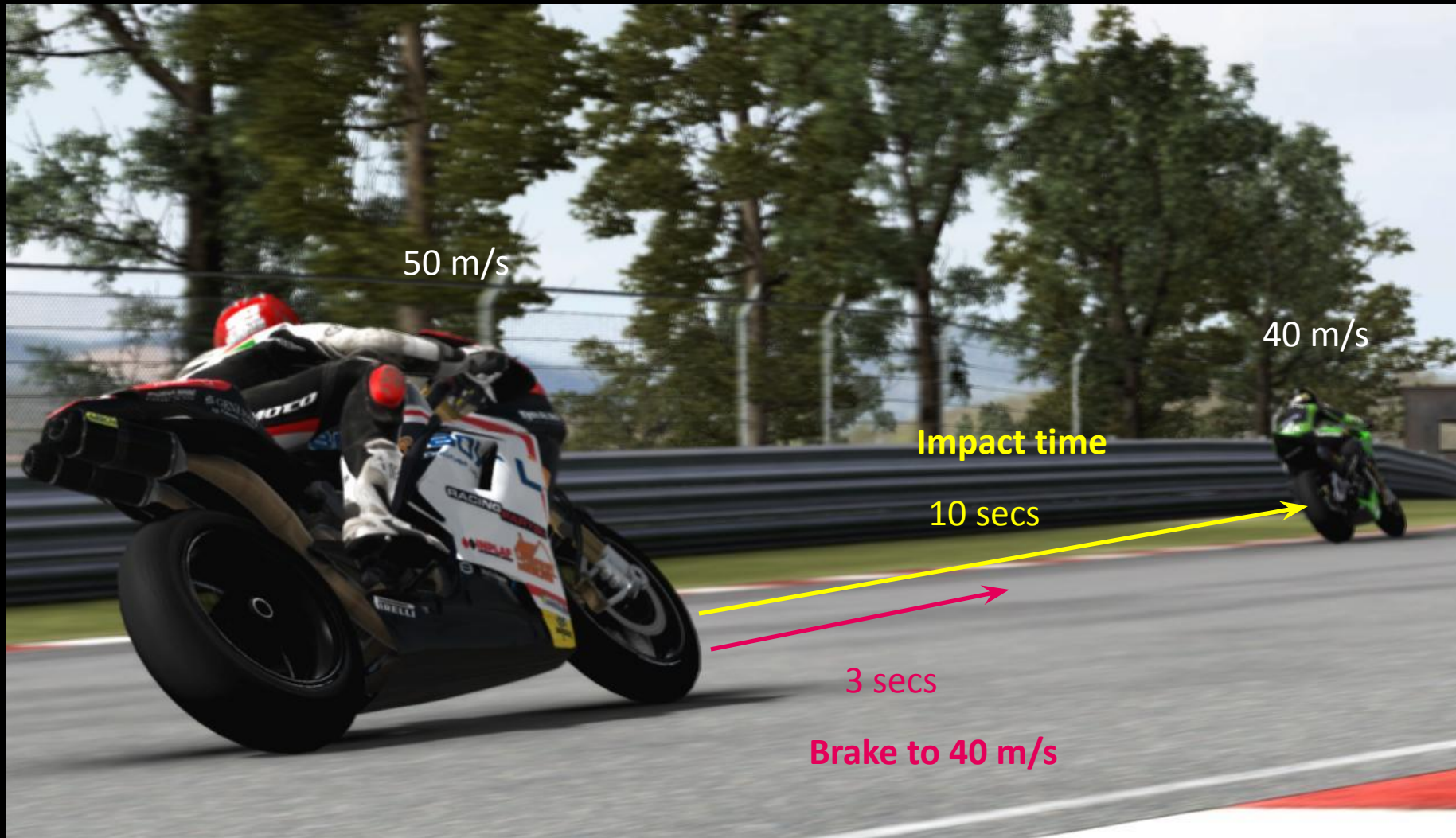
Recovery Mechanics

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

Avoiding



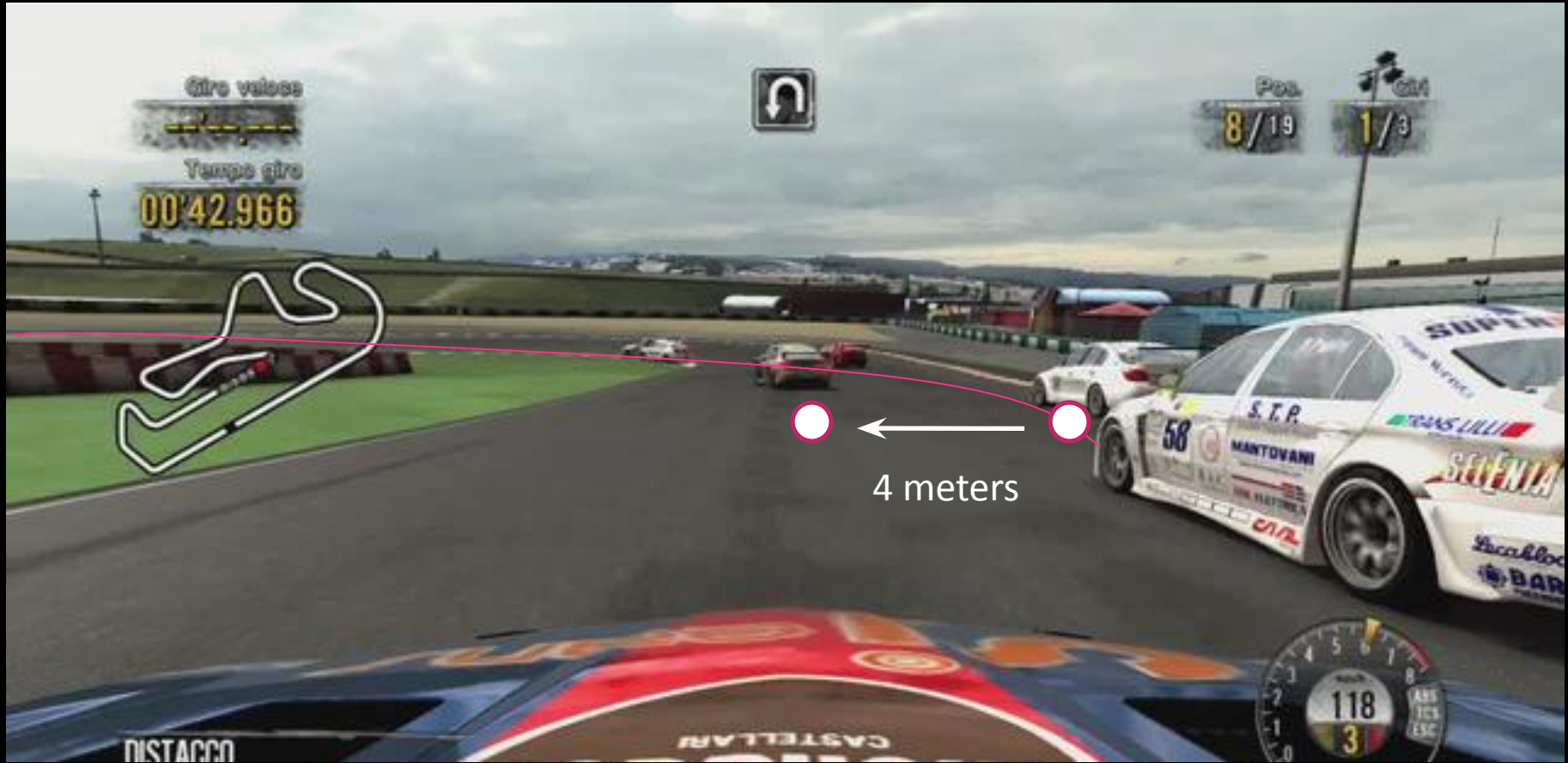
Avoiding



Overtake



Overtake



Overtake

- **Adding component to steer ($\text{Steer} = \text{SteerToTarget} + C$)**
 - **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



Bike AI





Part 2

A METHOD FOR OPTIMIZING AI PERFORMANCES

Game AI Conference, Paris June 2010



Fairness in racing games

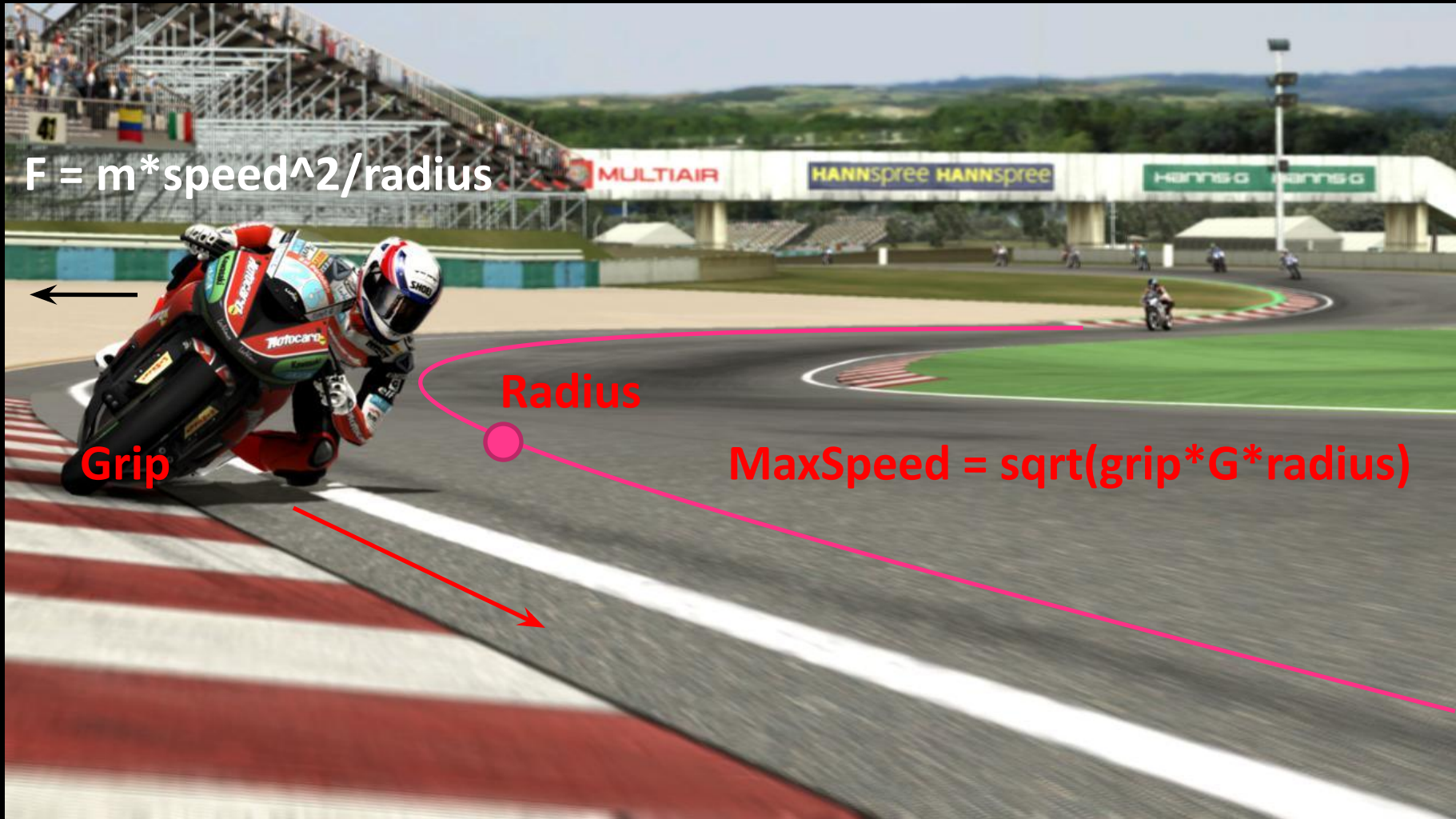
- **Common trick is using simplified (or helped) physics for Ais**
 - **Easier to obtain good performances (and tune)**
 - **Easier managing group situations**
 - **Visual effect not too realistic**
 - **Difficult to maintain a fair situation with the player**



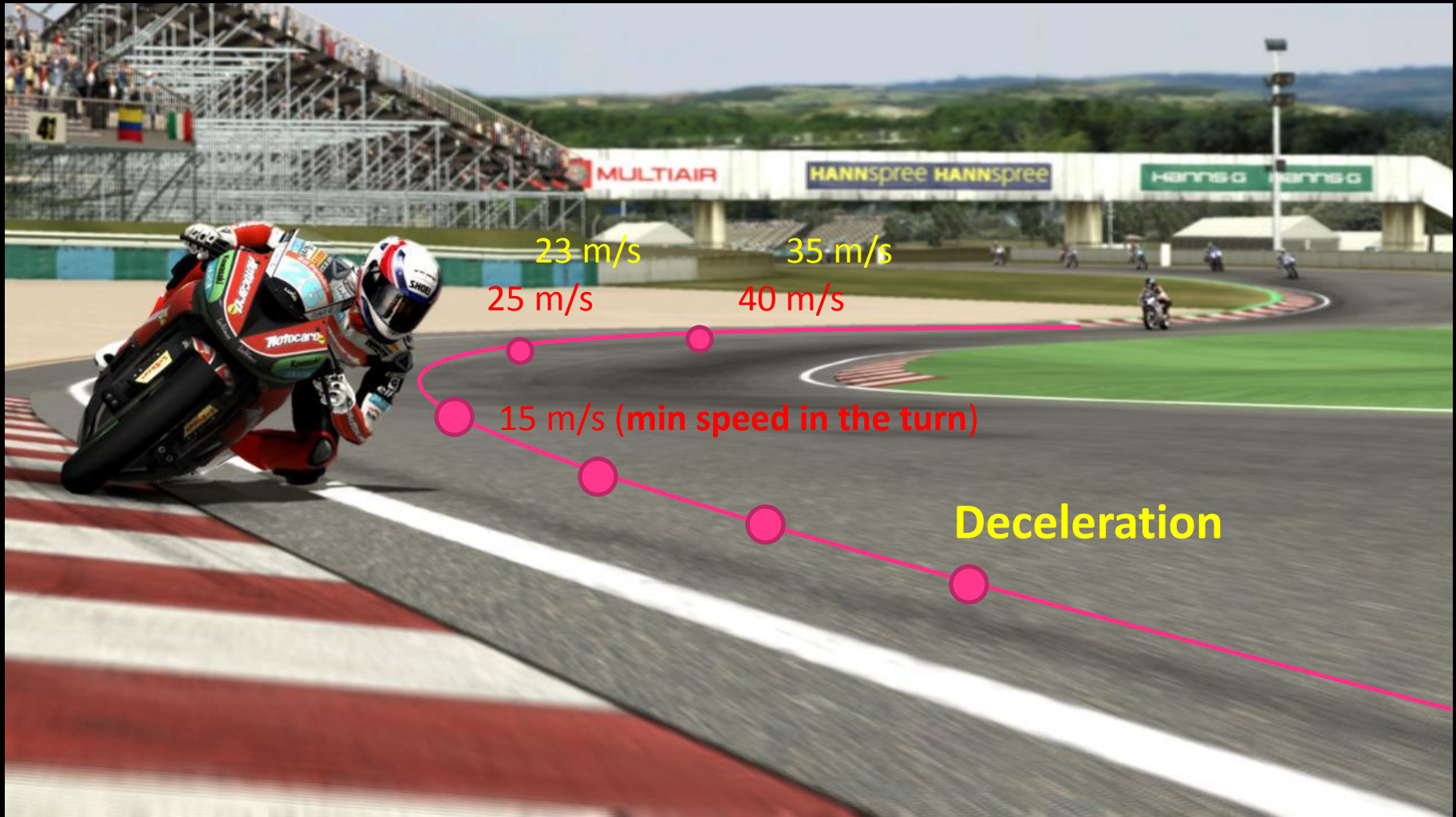
Fairness in racing games

- **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 algorithm 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



$$\text{MaxSpeed} = \sqrt{\text{grip} * \text{grip_mod_2} * G * \text{radius}}$$

Sector 2 (Grip Mod 2, Dec Mod 2)

Sector 1 (Grip Mod 1, Dec Mod 1)

$$\text{MaxSpeed} = \sqrt{\text{grip} * \text{grip_mod_1} * G * \text{radius}}$$



Iterative method

- **Detect sectors in an automatic way**
 - **Start when inverse radius $\neq 0$, 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 interactions could help (restart the process)**

Extra conditions

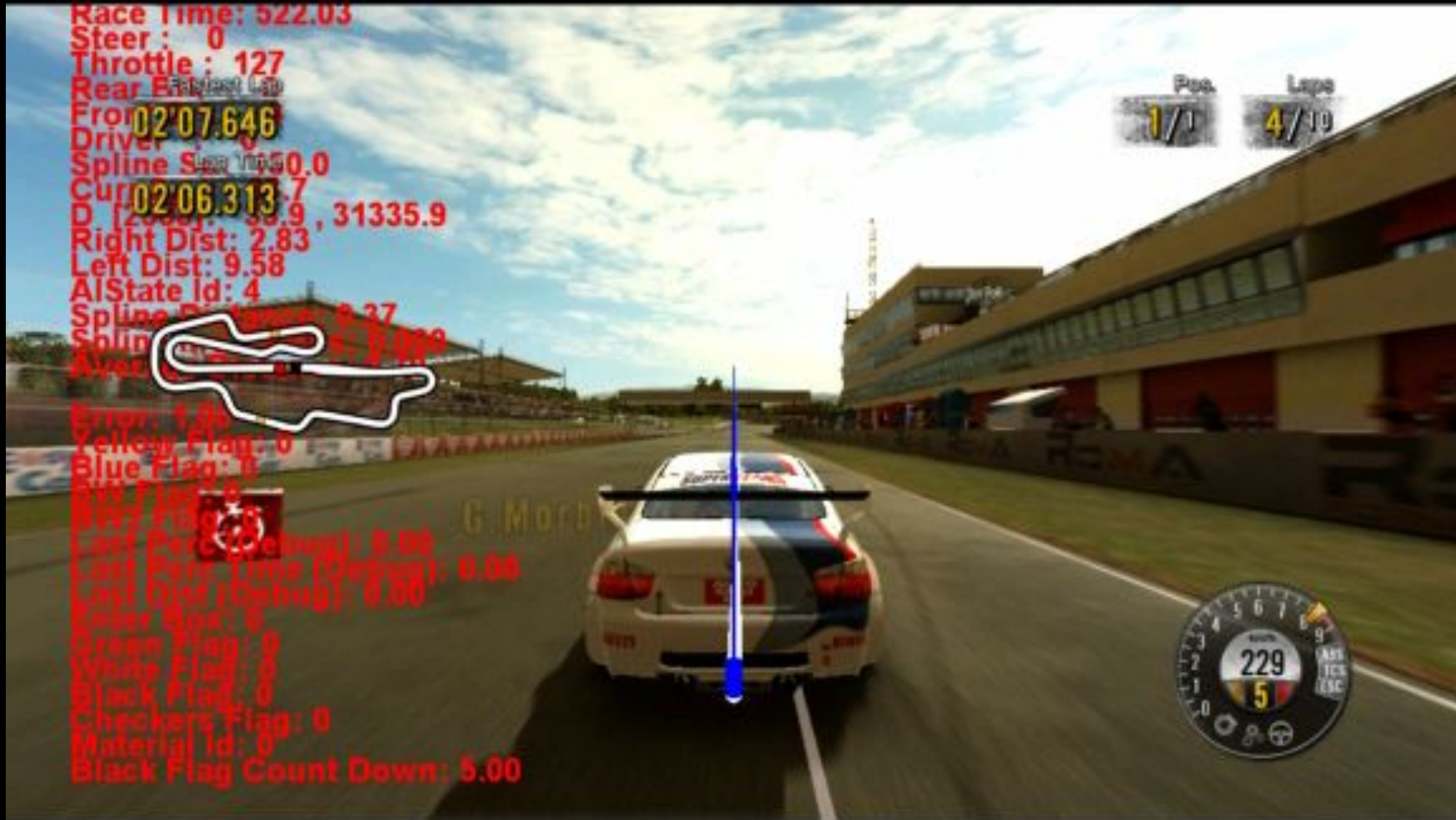
- **Considering only lap time is often not sufficient**
- **Need extra conditions to be satisfied**
 - **Out of track check**
 - **Distance from ideal line**
 - **Others (skid, wobble, wheelie, ...)**
- **Invalidate single lap or the entire trial when a condition is not satisfied**



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 management**
- **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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