Skylake

Simulated Car Racing with TORCS

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What is TORCS?

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The Open Racing Car Simulator is open source 3D car racing simulator.

In our case we have applied a **patch** to the original game that allows to create external agents using sockets, which is used in **SCRC** (Simulated Car Racing Championship).

That patch also applies **some restrictions** to the car.

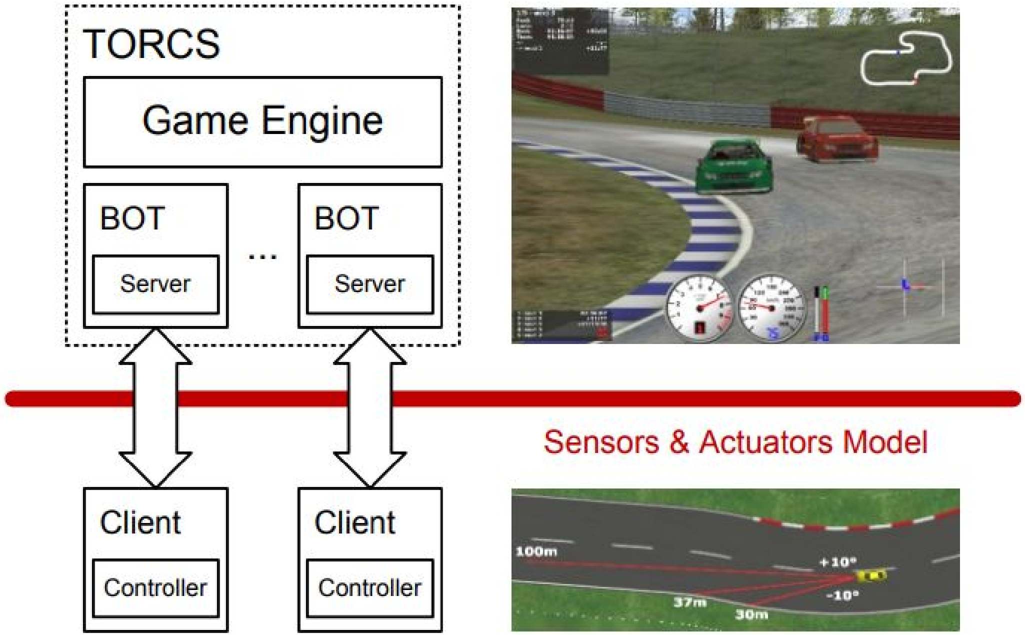

Fig 1. Communication between TORCS and the agent (https://arxiv.org/abs/1304.1672)

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How does the car sense the environment?
What can be used to control the car?

How does the car sense the environment?

Angle - angle between the car and road direction;
SpeedX, speedY, speedZ - car speed;
Track [0, 200m] - 19 range finders;
TrackPos - position of the car on the road (distance with road axis);
WheelSpinVel - Vector of 4 sensors with the rotation speed of the wheels.

And much more...
curLapTime; distRaced; distFromStart; opponents; z; focus; fuel; lastLapTime; racePos.

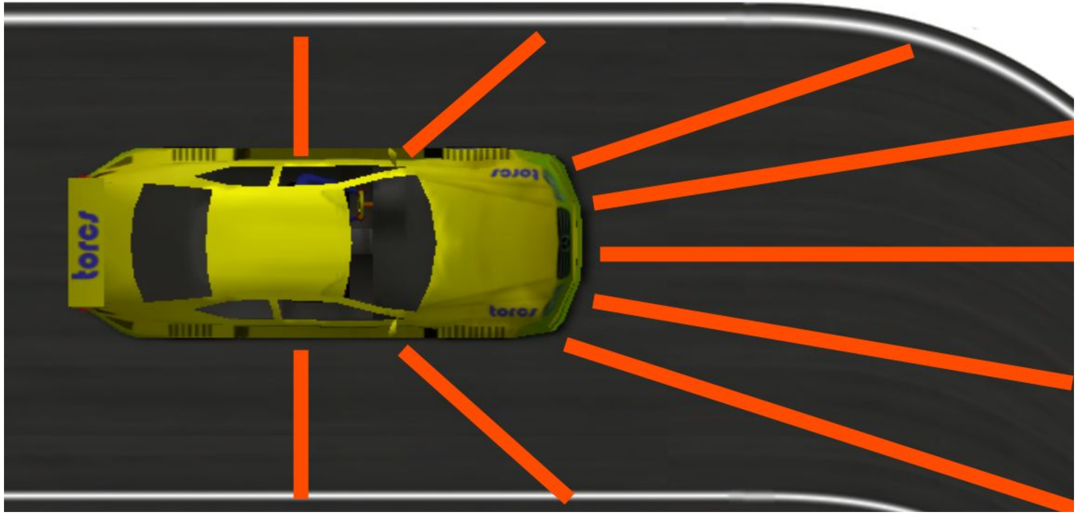

Fig 2. Example of the range finders
(Daniele Loiacono and Pier Luca Lanzi2013 Simulated Car Racing.GECCO-2013 presentation)

What can be used to control the car?

Acceleration [0,1] - Gas pedal where 0 means no gas and 1 fullgas;
Brake [0,1] - 0 means no brake, 1 full brake);
Clutch [0,1] - 0 means no clutch, 1 full clutch;
Gear -1,0,1,2,3,4,5,6 - Gear value
Steering [-1,1] where -1 and +1 means respectively full right and full left

Fig 3. Types of actuators (top left - brake, clutch and acceleration, right - steering wheel, bottom left - gear)

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What information does the agent retain from the sensors?

Localization and Mapping

Estimation of the robot's position:

$$lin = \frac{out_{\mathrm{right}} + out_{\mathrm{left}}}{2}$$

$$x_t = x_{t-1} + lin * \cos(\theta_{t-1}) \qquad y_t = y_{t-1} + lin * \sin(\theta_{t-1})$$

Where 'out' is the distance raced by each wheel, that is calculated with the rotational speed of each wheel

Estimation of the robot's global angle:

$$rot = \frac{out_{\mathrm{right}} - out_{\mathrm{left}}}{wheelsDist}$$

$$\theta_t = \theta_{t-1} + rot$$

Error associated
(slippage?)

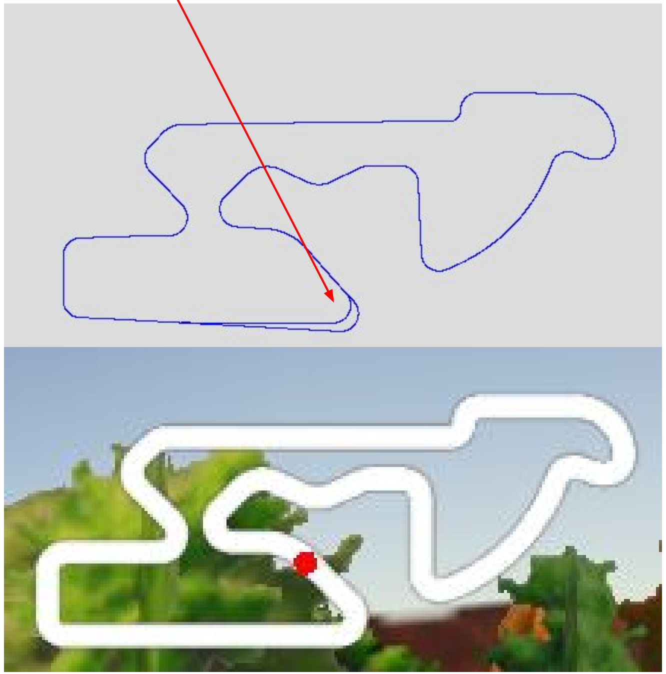

Fig 4. Mapping done using the position of the robot and the real map.

What is the best path for a race?

Minimum distance does not mean that the car will take less time to get there.

Minimum curvature path is easier to estimate using a **segment mapping** approach instead of a grid mapping.

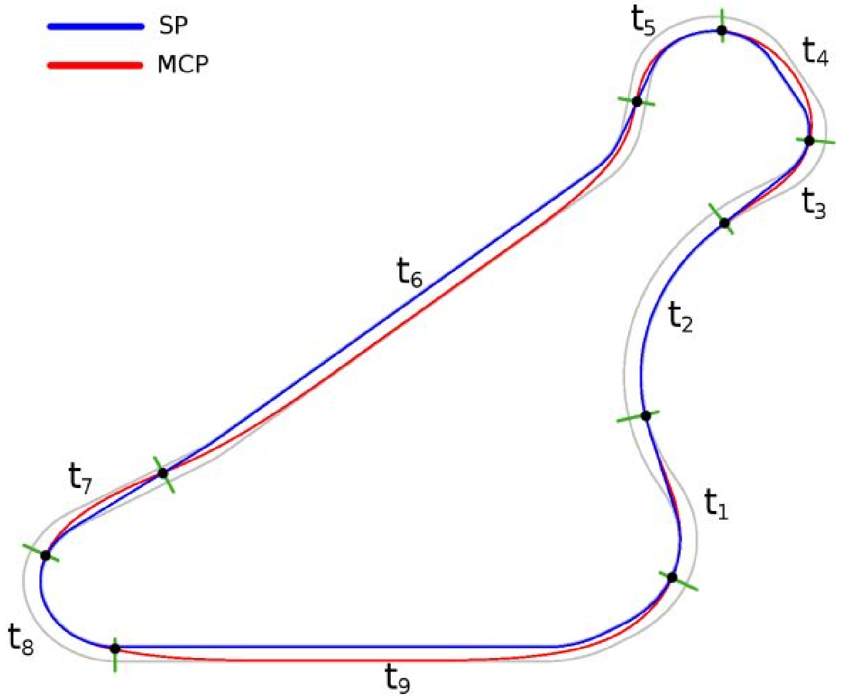

Fig 5. Shortest path vs minimum curvature path (http://ieeexplore.ieee.org/abstract/document/5593330/)

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How can a reactive agent obtain a good path?

How can a reactive agent obtain a good path?

Combining two approaches:

1. Follow the road in the middle of the track using trackPos (when it is 0, the agent is in the middle of the road);
2. Follow the **highest value from the vector field histogram**, which will lead to the corners.

Use the **approach 1 when there is no relevant track points in front** of the car;

When a curve gets closer (range finders will decrease their value under a given threshold) use **approach 2**.

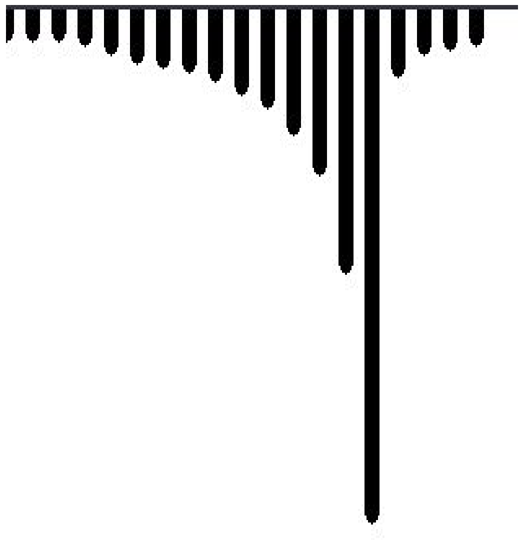

Fig 6. Polar representation using the range finders sensors (Vector field histogram)

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How does the agent control the actuators?

How does the agent control

...the steering?

The steering **simply applies the angle where the agent wants to go** according with the previous analysis of the path.

A tweak was applied to make it **easier to turn when the speed is smaller** and **harder to turn when the speed is higher.**

To simulate that behaviour, several “perfect” points were interpolated in order to achieve that.

... the gear?

The gear is simply controlled using the current **rotations per minute** and the current **gear**.

If the RPM are **over a specific threshold**, then the gear will **increase**.
If the RPM are **under a specific threshold**, it will **reduce** the gear.

Those thresholds are defined based on the torque wheel in order to maximize it.
(http://www.ls1gto.com/forums/showthread.php?t=334833)

How does the agent control the gas and brake pedal?

Using a fuzzy logic controller.

”**Fuzzy logic** is a form of many-valued logic that deals with **approximate**, rather than fixed and exact reasoning. Compared to traditional binary logic (where variables may take on true or false values), fuzzy logic variables may have a truth value that ranges in degree between 0 and 1.”

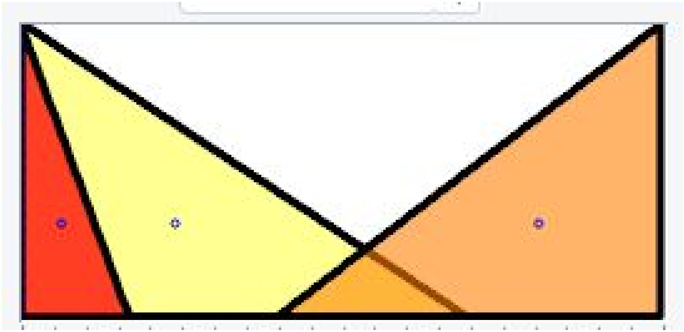

Fig 7. Sensor **speedX** mapped into 3 different categories (TOOSLOW - red, SLOW - yellow and FAST - orange).

Left side corresponds to 0 km/h and the right side to 300km/h

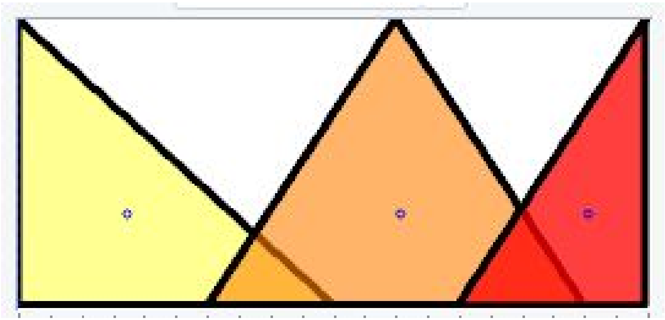

Fig 8. Sensor **distFront** mapped into 3 different categories (CLOSE - yellow, MID - orange and FAST - red).

Left side corresponds to 0 m and the right side to 200m

Rules choosen for the Fuzzy Logic

1. if **speedX is SLOW** then brake is NONACTIVE
2. if **speedX is FAST and distFront is CLOSE** then brake is FULLBRAKE
3. if **distFront is FAR** then accel is FULLGAS
4. if **distFront is CLOSE or distFront is MEDIUM** then accel is NORMAL
5. if **maxAngle is CLOSE_MID and speedX is FAST** then brake is MIDBRAKE
6. if **maxAngle is FAR and (distFront is CLOSE or distFront is MEDIUM)** then brake is FULLBRAKE
7. if **distFront is CLOSE** then brake is FULLBRAKE
8. if **distFront is MEDIUM and speedX is FAST** then brake is FULLBRAKE and accel is NORMAL

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Additional features

Additional Features

1. **Unstuck function**
   The routine is activated when the car is **facing the wrong direction and not moving**.
   After the car enters in this routine, it switches the **gear to reverse** and **starts positioning the car in the middle of the road again**. After being correctly positioned, the car goes back to normal state.

2. **Initial clutch to get acceleration**
   Its important to get an higher initial speed to **prevent to take a long time to start up**. To reach an higher acceleration on the beginning, **the clutch is kept higher** in order to achieve a boost.

Driver \ Track	Forza	Dirt 3	Alpine 1	E-Road	Alpine 2
Butz & Lonneker	11768.3	6216.2	8677.1	10253.3	7798
Onieva & Pelta	11997.2	6659.8	8386.5	9301.1	6826.4
Cardamone	9028.3	5439.8	7308	7716.3	6398.5
Perez & Saez	9028.3	5190.4	7661	6586.6	6272
Bernardi et al.	6685.9	4993.9	7184.2	8036.8	
Vrajitoru & Guse	7176.7	5788.3	6410.3	6384.4	
Wong	9781.6	5106.5	6480	6638.3	
Munoz	10577.6	4459.1	5548.7	7573.5	
Chiu	10424.9	901.6	6539	5124.3	5527.7
Szymaniak	6856.8	782.8	3711.9	4501.7	
Quadflieg & Preuss	12191.5	5502	7482.2		6398.6
SimpleDriver C++	*6122.7*	*3267.9*	*3376.7*	*3999.7*	*3216.9*
Skylake	9368.56	6382.11	6814.2	7369.66	6504.37
Skylake Position	7	2	6	6	3

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Questions?