# AI Driving

In this document, we are going through the main steps of this project and the way we improved the project to achieve the demonstrated final solution.

We began by drawing the track and making the cars work. Initially, these cars were generic cars that could either be driven by us or the algorithm. Then, these cars became what we call AI cars.

The car could be controlled by moving forward or stopping (if we were to use velocity as what was triggered by the user input). Still, we decided to control it by accelerating or slowing down (as using acceleration as what was triggered produced better results).

AI Cars contain a gene (matrix of weights) responsible for taking actions according to the environment inputs. Initially, the inputs for the genetic algorithm were the radars in front of the car, the velocity, and the angle of the vehicle, but soon we found out that the speed and the angle were not helping, so we stuck with the car radars only.

The scoring function was initially the travelled distance. However, giving it more thought, it made more sense for this to only happen in the first lap, as we want all the cars to do the first lap correctly and learn it. After the first lap, we want the vehicles to do it as fast as they can, so the scoring on the remaining laps is the corresponding average velocity added to the score when crossing the starting line.

Another issue we found was the background of the track. For some reason, not all the pixels had the specific colour we expected and as we were making the confirmation of being "dead" by the colour of the background the car was on top of, this led to many "index out of range" errors when the car was getting closer to the borders. It took us some time to understand that the issue was in the image we were using and not the code itself. This had to be manually solved.

Additional experiments were made to get the best output:

- The steering: what angles were best to give the car the flexibility needed to keep improving the way it performed the laps.

- Initial Velocity: if this was higher, the car couldn't acknowledge turning before it was too late and was already hitting the track borders.

- Origin of the radars: we experimented with the radars starting at the centre of the car. However, results were better with them in the front of the vehicle. This happens because the distance it was creating was not as accurate as what it hits the borders is the front and not the centre.

- Keeping the best genes: at first, the game was using the delta time (time between updates) to make the movement of the car smoother. This led to some problems, as the same car with the same gene could have different runs, depending on the time it took to update the game. With this, we could never be sure that a car was either the best or the worst, so the game loop had to be changed not to consider the delta time. With this fix, we could properly store the best cars for each generation and see the evolution of the generations.

- The movements allowed: in the beginning, the car could only accelerate, slow down, do nothing or steer left/right. The action of accelerating or breaking is independent of the action of steering; thus, it wouldn't make sense not to give the AI Cars the option to make both actions simultaneously. Therefore, in the final solution, we implement a combination of them.

This way, the car can accelerate, accelerate and steer left, accelerate and steer right, break, and break and steer left, break and steer right, do nothing, steer left or steer right.