Challenge UTAC : automation of a Lotus 7 for a highway circuit course

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1. Overview

This study is part of the 2nd year autonomous robotics project at **ENSTA Bretagne**. This is our school's first participation, **not counting the simulation trials**.

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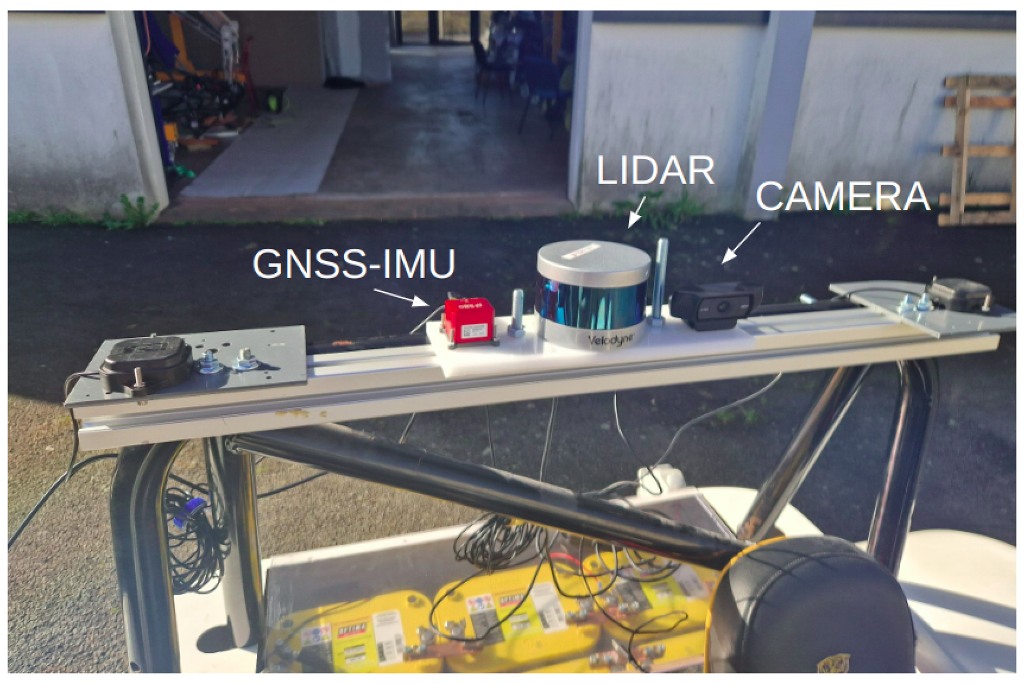
2. A wide range of technologies

We use numerous sensors and actuators to enable the vehicle to analyze its environment. In particular, **three sensors** are used to control the robot:

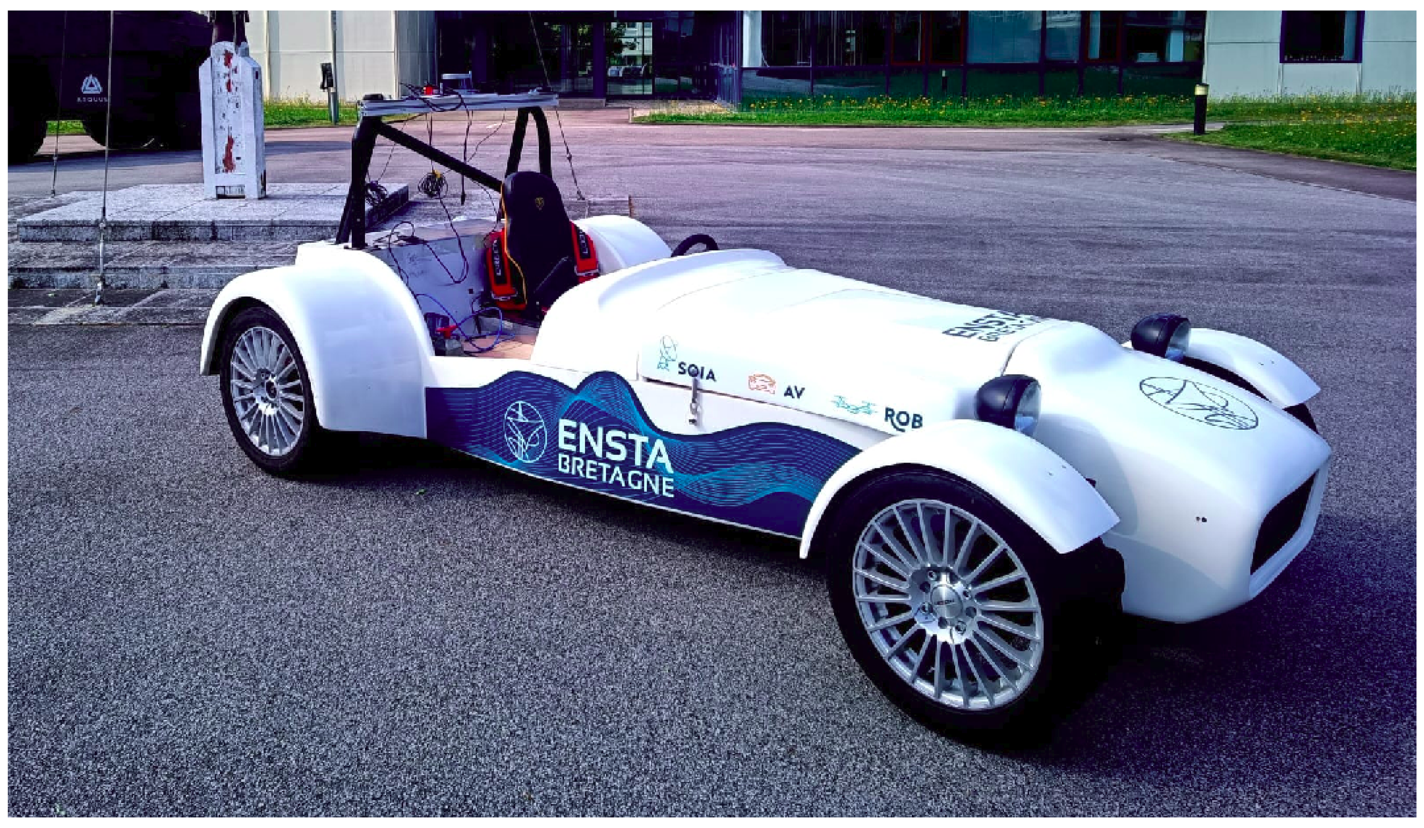
The main sensors	
LIDAR	Used to create a 3D representation of the environment. Delivered format: ROS2 - `PointCloud2`
CAMERA	Used to scan the road and detect white lanes. Delivered format : `np.ndarray`
GNSS-IMU	Used to represent the car's pose

3. Sensor installation



4. The car/robot

Our car is a **Lotus 7 Series 2**, formerly hybrid, which became **fully electric** when it took part in the UTAC Challenge. It can be driven manually, but its actuators (electric motor, steering and brake motors) and other sensors (see 3) enable it to locate and move **autonomously**.

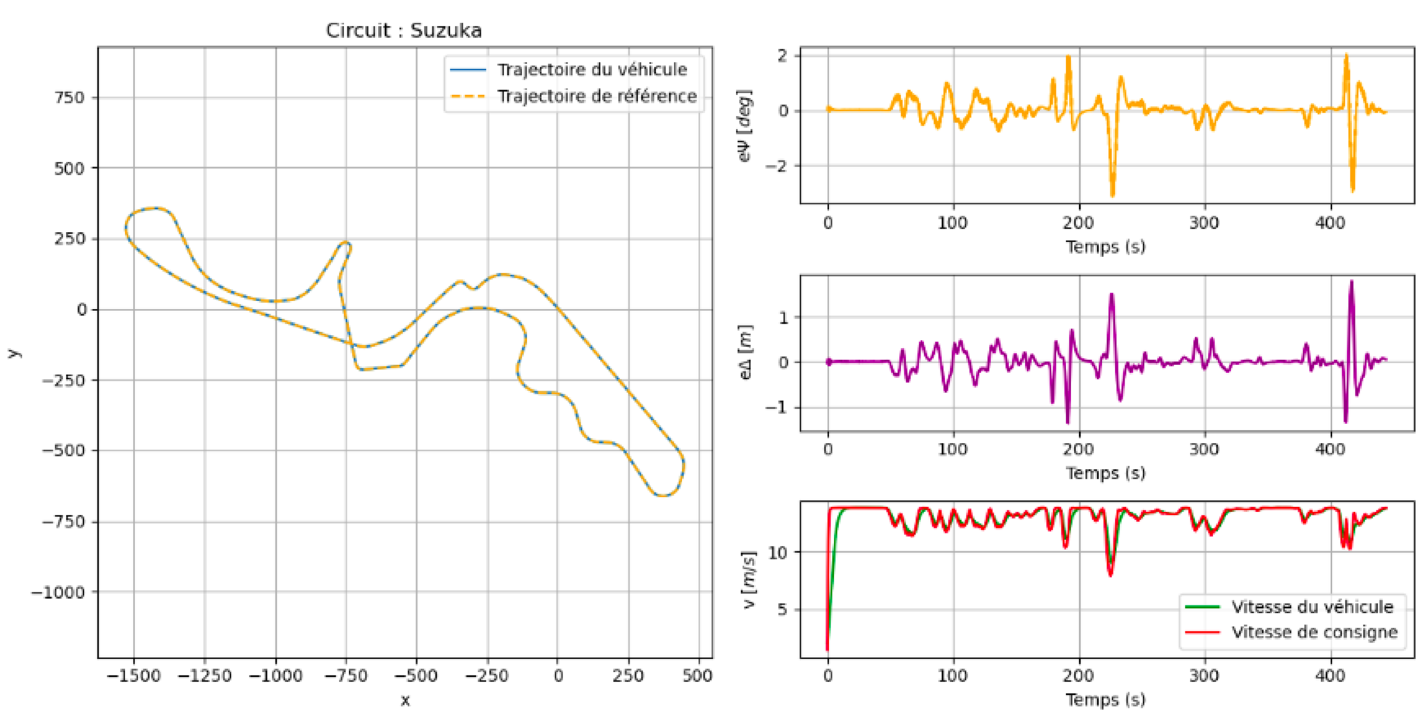


5. Obstacle detection

Our **Velodyne Puck Lite** lidar enables us to retrieve a 3D model of our environment via **ROS2** communication. A **DBSCAN** segmentation algorithm then allows us to materialize obstacles by "families", to manipulate concrete objects. Finally, we implement code to **identify the presence of obstacles**.

6. Control and inertial guidance

The vehicle is controlled by regulating the errors e_Δ and e_ψ through the implementation of **two PID correctors**. This ensures that the vehicle is centered on the track and parallel to the tangent of the road curve.



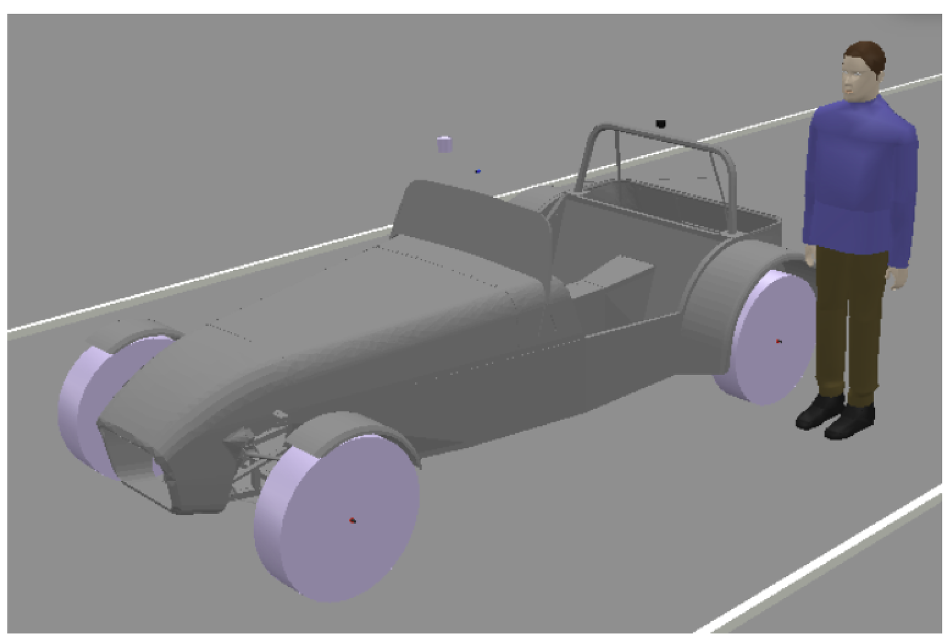
$$\begin{cases} \dot{x} = v.\cos(\theta).\cos(\delta) \\ \dot{y} = v.\sin(\theta).\cos(\delta) \\ \dot{\theta} = v.sin(\delta) \\ \dot{v} = u_1 \\ \dot{\delta} = u_2 \end{cases}$$

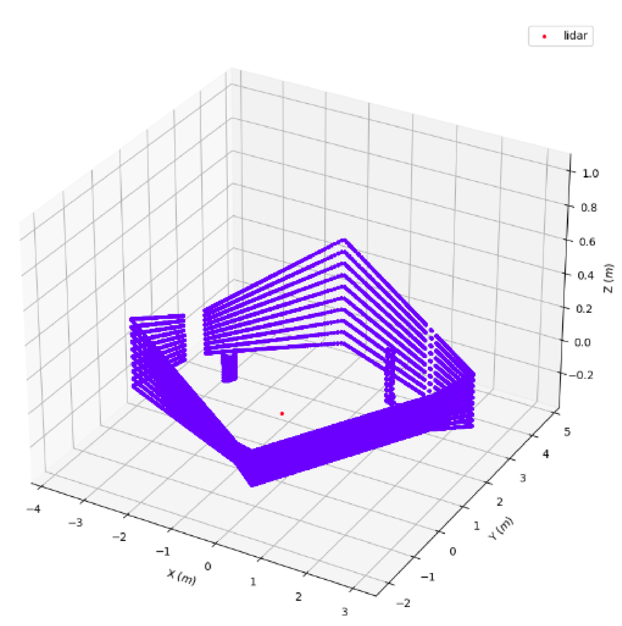
7. Line following

Line tracking is a crucial issue for an autonomous vehicle. We decided to use a single camera located above the vehicle to determine several road-related parameters: the **position of the vehicle between the lines** e_Δ, the **angular distance between the robot and the track** e_ψ, and the **curvature** C of the latter.

8. Simulation and pratical testing

Whether it is directional control, obstacle detection or GPS geolocation, all the functions currently implemented in the vehicle have been tested using **CoppeliaSim**. This first part enabled us to validate all the theory employed, with the aim of implementing it in our vehicle. ***Eventually***, **difficulties encountered during vehicle assembly** prevented us from validating our algorithms in situ.





9. Conclusion

Here are some **key takeaways**:

1. Successfull integration of sensors
2. Great simulations via CoppeliaSim
3. Interdisciplinary collaboration
4. More time needed to compute IRL cases
5. Simulation and practice should be closely integrated

10. Special thanks

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