Towards a Mixed-Reality framework for autonomous driving

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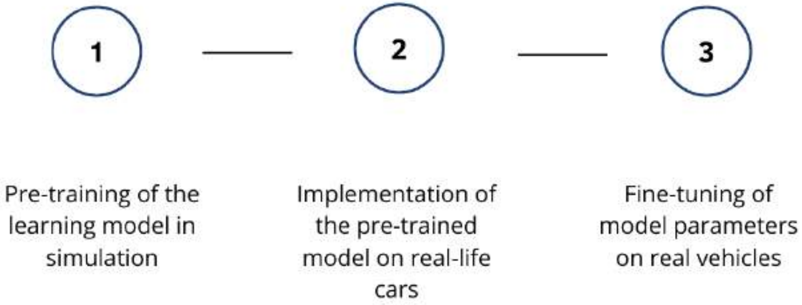
Autonomous driving

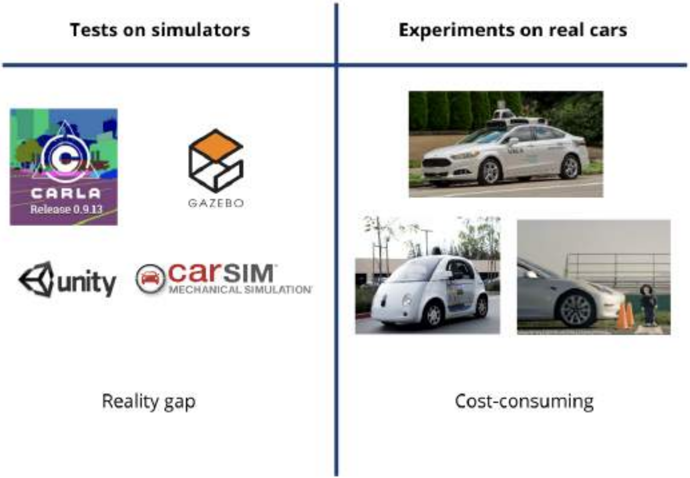
- **1939** : First "self-driving" car created by General Motors.
- **25,000** : number of lives that will be saved if 90 % of cars are self-driving on US [1].
- **2017** : A failed prediction for having a fully autonomous driving.
- **14 billion** : kilometers of on-road testing needed to demonstrate the reliability of the cars [3].

Challenges of autonomous driving

The process of learning and training for autonomous vehicles can be summarized in three steps :



Challenges of autonomous driving



Mixed-Reality environments

Real world and virtual world objects belong together to a single environment.

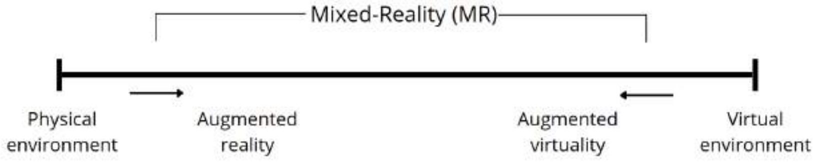


Figure 1: Virtuality continuum [4]

Motivation

Why using MR testing for autonomous driving ?

- Repeatability of experiments to train an agent.
- Reduction of safety risks.
- Simplification of debugging.
- Multi-agent learning.
- Spatial flexibilty.

Mixed-Reality for self-driving vehicles

- Detection of a virtual pedestrian using LiDAR.

Figure 2: Virtual pedestrian [7]

Mixed-Reality for self-driving vehicles

- Detection of a virtual pedestrian using LiDAR.

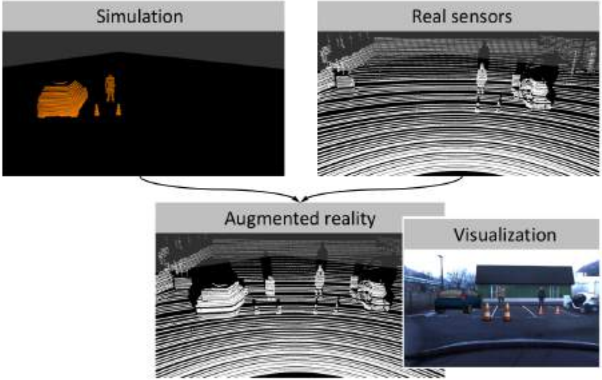


Figure 3: Introduction of virtual elements [2]

Mixed-Reality for self-driving vehicles

- Training of a mobile robot in a multi-vehicle multi-lane environment.

Figure 4: Multi-vehicle environment [5]

LiDAR vs Depth cameras

	LiDAR	Depth cameras
High costs	x	-
Accuracy	x	-
Interpretation of roadway information	-	x
Dark or low illumination	x	-
Edge detection	x	x
Lane tracking	-	x

Comparison between sensors in autonomous vehicles [6]

Architecture of the framework

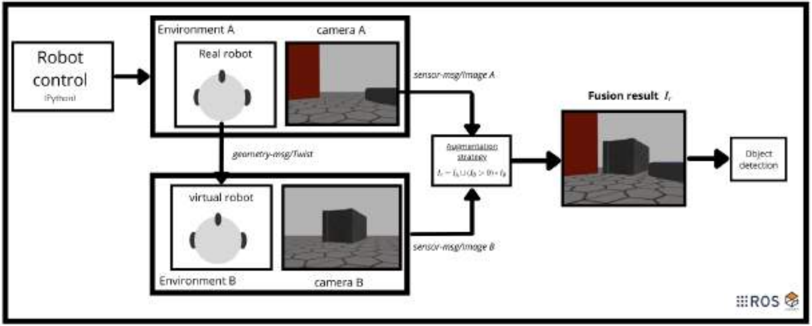
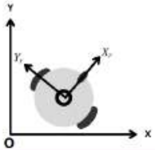
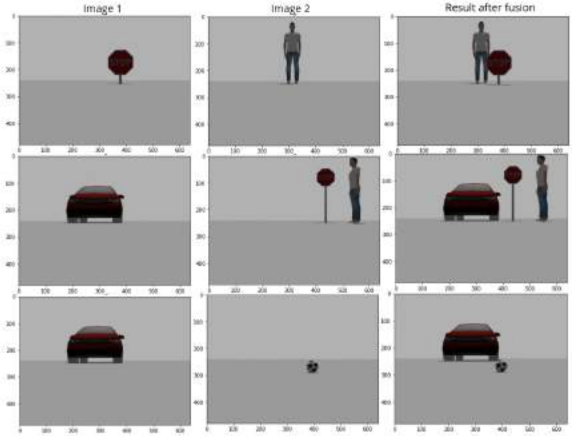


Figure 5: Overview of the proposed framework enabling the physical coupling of two virtual robots and the fusion of their perception using a vision-based startegy.

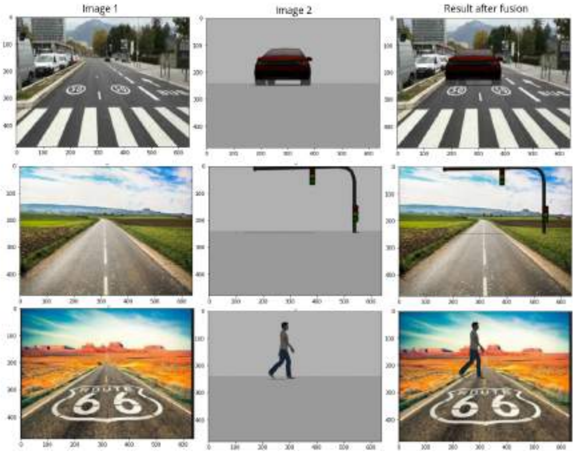
Experimental setup

Differential wheeled robot $\begin{pmatrix} \dot{x}_r \\ \dot{y}_r \\ \dot{\theta}_r \end{pmatrix} = \begin{pmatrix} \cos\theta_r & 0 \\ \sin\theta_r & 0 \\ 0 & 1 \end{pmatrix} \begin{pmatrix} v_r \\ \omega_r \end{pmatrix}$	
Intel RealSense d435 - active stereo depth camera	
Software tools : Middleware ROS. Simulator Gazebo. Library : OpenCV	ROS GAZEBO OpenCV

Results of the fusion of virtual images



Results of the fusion of a virtual and real image



The RM framework

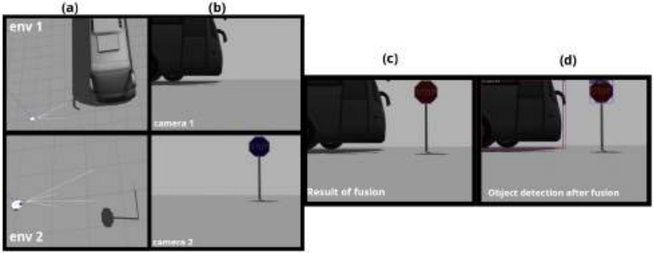


Figure 6: Overview of the simulation in the RM framework (a) robot's environmnet (b) robot's perception (c) output of the fusion (d) object detection applied after the fusion

The RM framework

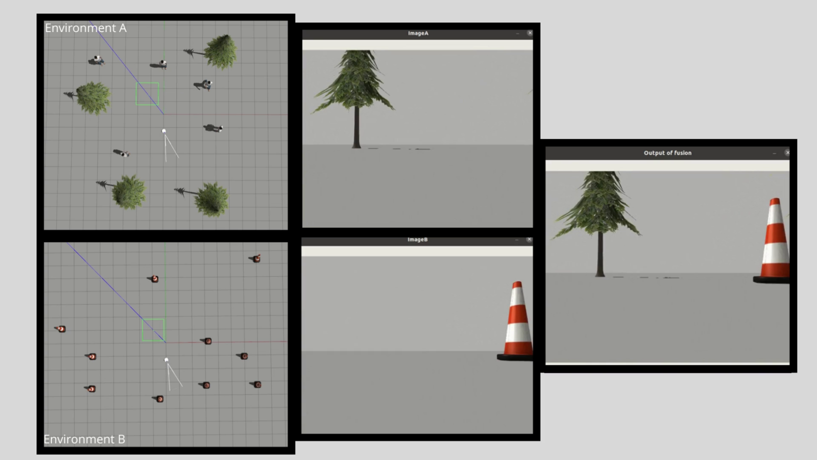


Figure 7: Demonstration of a simulation in the proposed framework.

Conclusion

Proposed work

- Preliminary work towards a mixed-reality framework based on vision.
- Fusion between two images (virtual and real).
- Detection of the objects after the fusion.

Conclusion

Perspectives

- Introduction of a real robot.
- Improvement of digital twining to avoid drifts.
- Introduction of dynamic obstacles.
- Testing learning-based models for critical situations.

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