Simulation framework for Tele-Operated Driving

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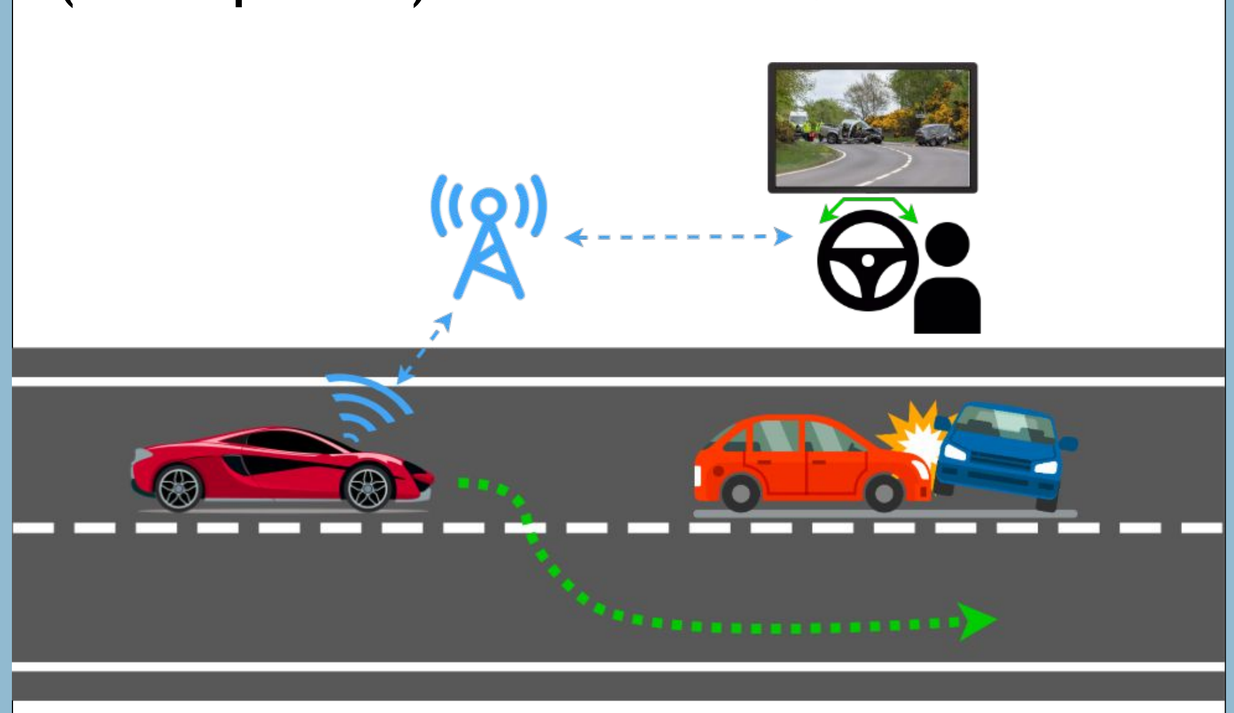
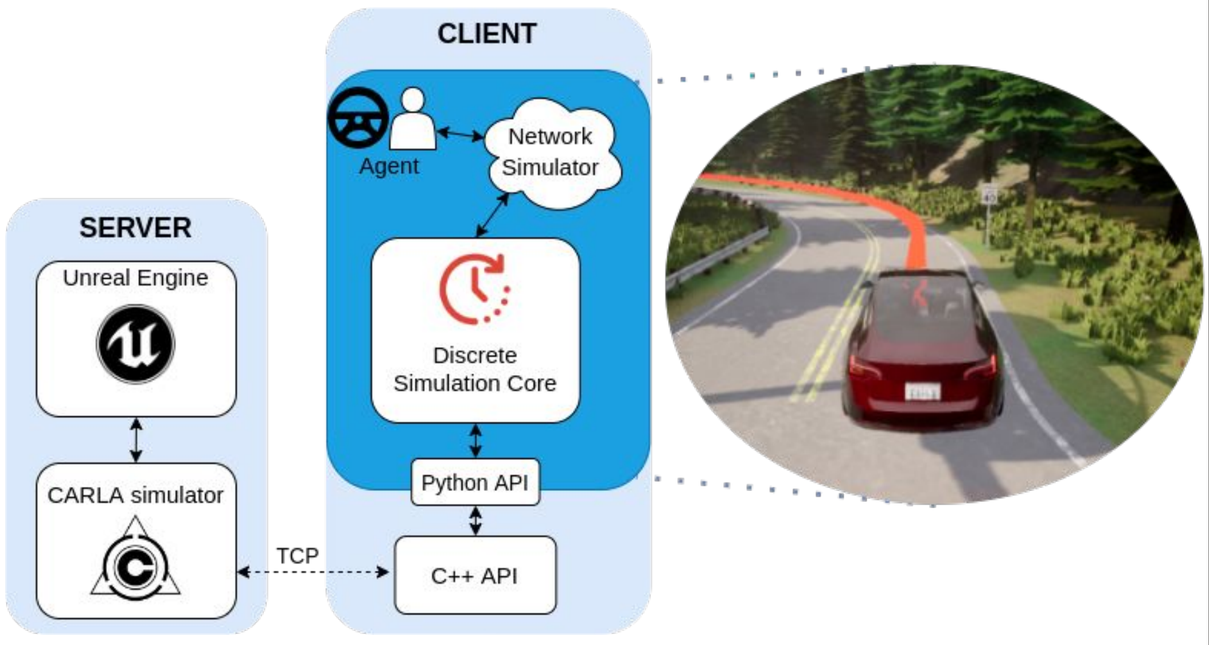
What is Tele-Operated Driving?

Tele-Operated Driving is a service that uses the cellular network to allow a remote driver (Tele-Operator) to control a car.



Simulator Architecture

Our Tele-Operated Driving simulator defines an additional layer on top of CARLA.
We simulate communication delay applied on the messages between the driven car and the Tele-Operator.
The simulator uses an agent with a PID controller to emulate the human behavior of a driver.

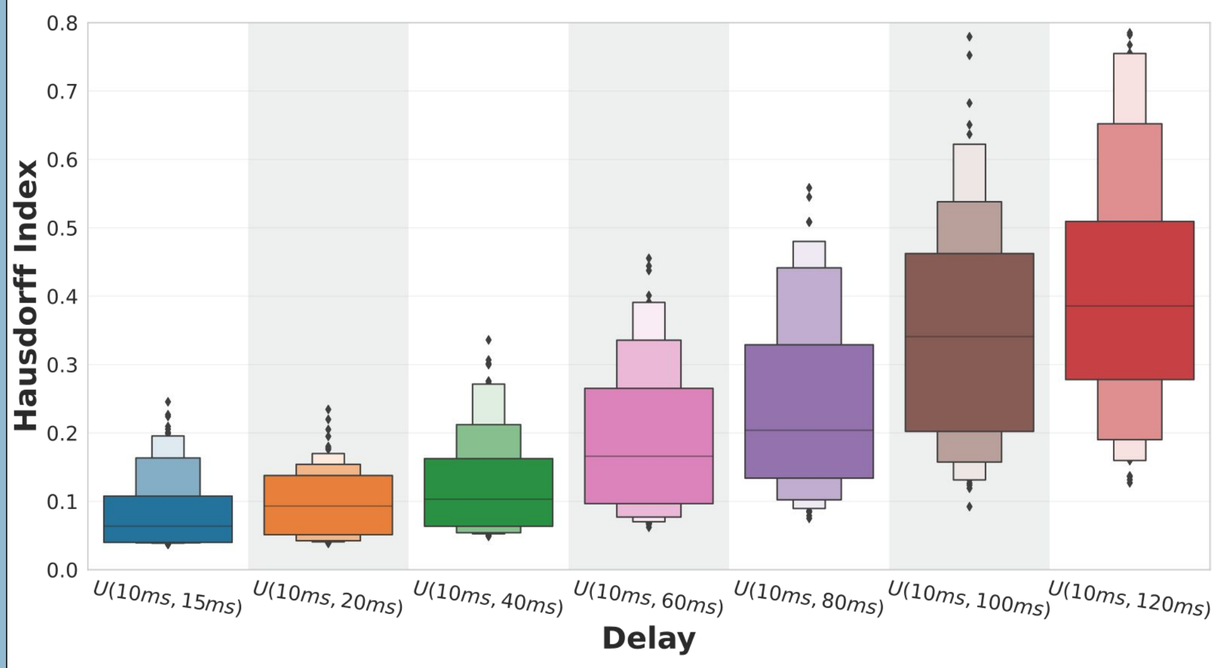


Method

- **We Simulate the same road route several times by applying different network delays and saving the trajectory.**
- **We Use the Hausdorff Distance to compare the trajectories obtaining by different simulations with respect to the ideal one.**

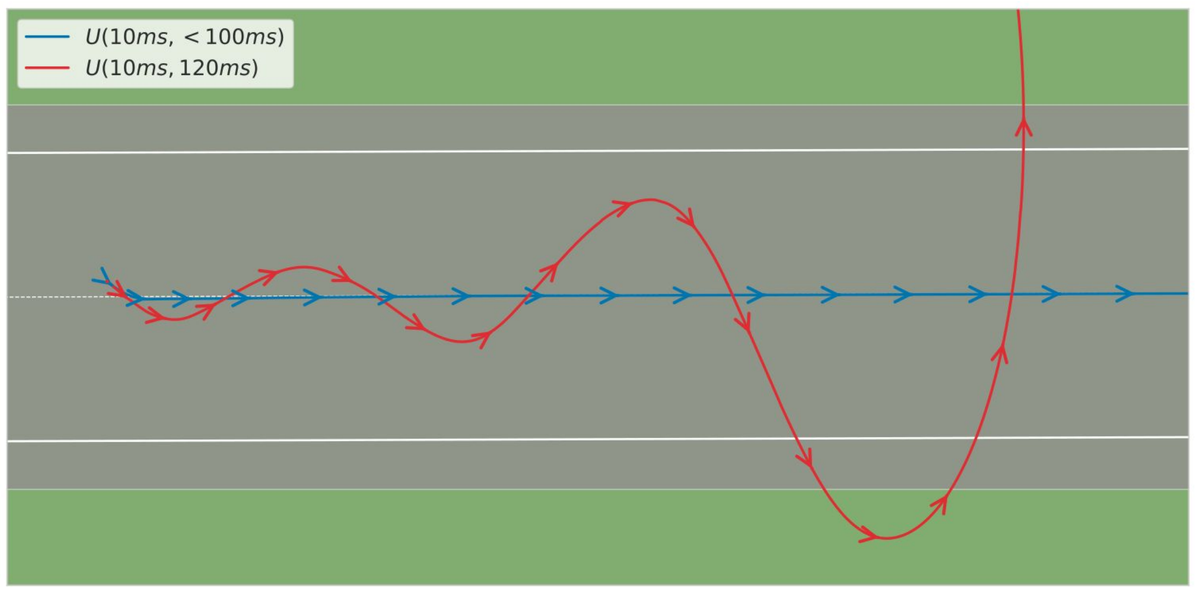
$$Dist_{Hausdorff}(T_H, T_A) = \max\{ \max_{\rho_i^\eta \in T_H} \min_{\rho_j^\alpha \in T_A} dist(\rho_i^\eta, \rho_j^\alpha), \max_{\rho_j^\alpha \in T_A} \min_{\rho_i^\eta \in T_H} dist(\rho_i^\eta, \rho_j^\alpha) \}$$

Preliminary Results



- **Average speed: 40 km/h**
- **98% accidents free with maximux delay.**
- **Hausdorff index, given no accidents, is always less than 1 meter.**

However, if the delay increases, in the worst case, the Tele-Operator loses control.



Future Works

- **Augmented Context**
  - **Computed on the edge of the network**
- **Assisted Tele-Operated Driving**
  - **Anticipate instructions in dangerous situations**

Reference

[1] 5GAA, C-V2X Use Cases Volume II: Examples and Service Level Requirements; October 2020. https://5gaa.org/wp-content/uploads/2020/10/5GAA_White-Paper_C-V2X-Use-Cases-Volume-II.pdf
[2] Dosovitskiy, A., Ros, G., Codevilla, F., Lopez, A., & Koltun, V. (2017). CARLA: An Open Urban Driving Simulator. Proceedings of the 1st Annual Conference on Robot Learning, 1-16.
[3] Sousa, R. S. D., Boukerche, A., & Loureiro, A. A. F. (2020). Vehicle Trajectory Similarity: Models, Methods, and Applications. ACM Comput. Surv., 53(5). doi:10.1145/3406096

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