

Realistic and Scalable Floating Car Observer Detection in SUMO Derived from Co-Simulation

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Abstract. Floating Car Observers (FCOs) are perception-equipped, connected vehicles that share object-level detections of surrounding traffic participants via V2X communication [1], [2], [3]. By extending classical Floating Car Data (FCD) with onboard sensor outputs, FCOs enable mobile, infrastructure-independent traffic state estimation with broad spatial coverage. FCO-derived observations are therefore highly relevant for ITS applications where a complete and accurate picture of the current traffic state is essential. A key challenge in FCO research is the simulation-based development and evaluation of algorithms that rely on realistic detection inputs. Microscopic traffic simulators like SUMO operate at a high level of abstraction and do not natively model sensor physics or the stochastic behavior of modern learning-based perception systems. Existing approaches approximate FCO detectability via simple distance thresholds [1] or 2D ray tracing [4], [5], producing simplified detections not grounded in real-world sensor capabilities. Furthermore, they assign binary detected/undetected labels and fail to capture the uncertainty, position error, and sensor-dependent characteristics of real 3D object detectors.

To address this gap, we present a scalable neural network-based observation model [6], [7] that emulates the outputs of state-of-the-art 3D object detectors directly within SUMO. Training data is generated through a synchronized SUMO–CARLA [8] co-simulation, in which observer vehicles are equipped with virtual camera and LiDAR sensors following the NuScenes sensor setup [9]. Detections are produced by fine-tuned 3D detection models covering LiDAR-only, camera-only, and multimodal configurations, and capture realistic imperfections including localization error and missed detections. A lightweight neural network, trained on abstract scene representations natively available in SUMO—capturing surrounding traffic participants and infrastructure geometry—then reproduces these detection outcomes at runtime without requiring high-fidelity rendering or costly detector inference. This enables large-scale SUMO simulations with realistic FCO perception: detection evaluation runs in under 10 ms per FCO, on par with 2D ray tracing, while achieving over 93 % detection accuracy compared to CARLA ground truth.

At the conference, we present via a poster and live demonstration how the detection module is trained, illustrating the full process from co-simulation to a scalable detection module. The detection module and trained neural network weights are shared via an open-source repository (<https://github.com/urbanAlthi/fco>, shows a first version) to enable other researchers to use the detection module for Floating Car Observer and general detection-based use cases in SUMO.

Keywords: Floating Car Observers, Traffic State Estimation, SUMO, Co-Simulation, Neural Network, Extended Floating Car Data

References

- [1] Y. Zhang, M. Ilic, and K. Bogenberger, "A novel concept of traffic data collection and utilization: Autonomous vehicles as a sensor," in *2023 IEEE 26th International Conference on Intelligent Transportation Systems (ITSC)*, 2023.
- [2] W. Ma and S. Qian, "High-resolution traffic sensing with probe autonomous vehicles: A data-driven approach," *Sensors*, vol. 21, no. 2, p. 464, 2021.
- [3] R. Florin and S. Olariu, "Real-time traffic density estimation: Putting on-coming traffic to work," *IEEE Transactions on Intelligent Transportation Systems*, vol. 24, no. 1, pp. 1374–1383, 2022.
- [4] M. Ilic, M. Pechinger, T. Niels, E. Nexhipi, and K. Bogenberger, "An open-source framework for evaluating cooperative perception in urban areas," 2024. DOI: [10.13140/RG.2.2.21224.89602](https://doi.org/10.13140/RG.2.2.21224.89602).
- [5] J. Düensing and R. Hoyer, "Determining the influence of multiple simulation parameters on fco detection coverage," *Journal of Advances in Information Technology*, vol. 16, no. 2, 2025.
- [6] J. Gerner, D. Röble, D. Cremers, K. Bogenberger, T. Schön, and S. Schmidtner, "Enhancing realistic floating car observers in microscopic traffic simulation," in *2023 IEEE 26th International Conference on Intelligent Transportation Systems (ITSC)*, 2023, pp. 2396–2403. DOI: [10.1109/ITSC57777.2023.10422398](https://doi.org/10.1109/ITSC57777.2023.10422398).
- [7] J. Gerner, K. Bogenberger, and S. Schmidtner, "Temporal enhanced floating car observers," in *2024 IEEE Intelligent Vehicles Symposium (IV)*, 2024, pp. 1035–1040. DOI: [10.1109/IV55156.2024.10588538](https://doi.org/10.1109/IV55156.2024.10588538).
- [8] A. Dosovitskiy, G. Ros, F. Codevilla, A. M. López, and V. Koltun, "CARLA: an open urban driving simulator," *CoRR*, vol. abs/1711.03938, 2017. arXiv: [1711.03938](https://arxiv.org/abs/1711.03938). [Online]. Available: <http://arxiv.org/abs/1711.03938>
- [9] H. Caesar et al., "Nuscenes: A multimodal dataset for autonomous driving," *CoRR*, vol. abs/1903.11027, 2019. arXiv: [1903.11027](https://arxiv.org/abs/1903.11027). [Online]. Available: <http://arxiv.org/abs/1903.11027>