

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

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