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From Co-Simulation to Scalable FCO Detection in SUMO

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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. 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 or 2D raytracing based detections, which produce simplified detections not grounding in real-world deteciton capabilities. Further they assigns binary detected/undetected labels but fails 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 that emulates the outputs of state-of-the-art 3D object detectors directly within SUMO. xxx the models are trained with data from SUMO – CARLA Co-simulation xxx Training data is generated through a synchronized SUMO–CARLA co-simulation, in which observer vehicles are equipped with virtual camera and LiDAR sensors following the Nuscenes sensor setup. Detections are produced by fine-tuned 3D detection models for lidar, camera and multimodal based detectors and capture realistic imperfections including localization error, missed detections. A lightweight neural network trained on abstract scene representation all available in sumo simulations capturing traffic participants and infrastructure scene representations then reproduces these detection outcomes at runtime without requiring high-fidelity rendering or costly detector inference, enabling large-scale SUMO simulations with realistic FCO perception. xxx the result is that FCO detectoins can be evaluation ¡10ms per FCO deteciton evalauation beeing almost in par with 2D raytracing methods but achieving ¿93

We will demonstrate the framework live in SUMO, showing how FCO detections behave across varying penetration rates and sensor configurations, and how they differ from idealized ray-tracing baselines.

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

1. First section

1.1 Subsection

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1.1.1 Three levels of headlines may be used

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Table 1. *Table captions are automatically placed above the tables.*

Hazard Class	**A 1 to A III**
Flash point	$< 21°C / > 55°C$
Density at $15°C$	$720\ ^{kg}/_{m^3}$ to $860\ ^{kg}/_{m^3}$
Kinematic Viscosity	$0,65$ to $4,0 \cdot 10–6\ ^{m^2}/_{s}$

Tables and Figures are automatically centered.

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1. Numbering may be used, too.
2. ...

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$$x + y = z \tag{1}$$

$$a^2 + b^2 = c^2 \tag{2}$$

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2. Second section

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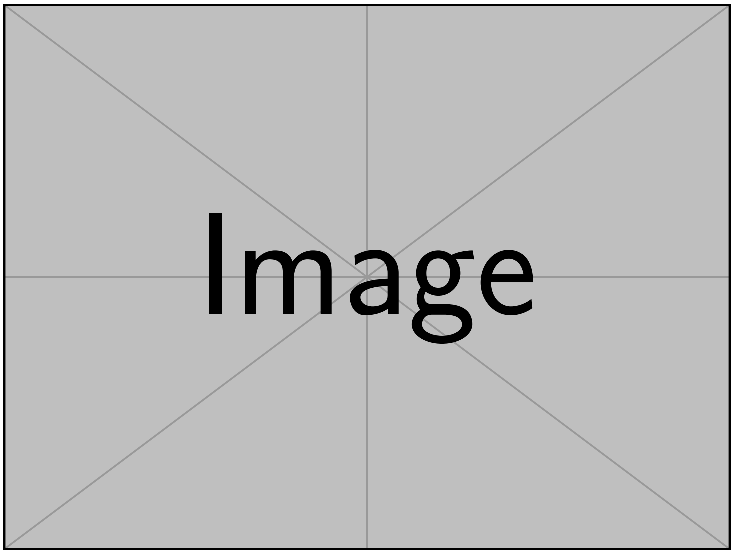

Figure 1. *A figure caption is automatically placed below the illustration.*

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