講演番号	366

Virtual Validation Methodology and Credibility Assessment for Automated Driving Systems with Applications to NCAP 2029

Prof. Dr. Reza Rezaei[1)], Gnana Prakash Reddy Madduri[1)], Abhishek Singh Kudavale[1)], Dr. Christian Lang[1)], Kento Fukuhara[1)]

1) IAV GmbH
Rockwellstr. 1, 38518 Gifhorn, Germany
(E-Mail: reza.rezaei@iav.de)

KEY WORDS: **Virtual AD/ADAS validation, Simulation credibility, Scenario extraction**

Virtual validation is becoming essential for the development and assessment of automated driving (AD) systems, particularly for SAE Level 3 and above, where physical testing alone cannot provide the breadth of scenario coverage required for future homologation and consumer-test programs. At the same time, regulatory frameworks such as EU 2022/1426 and the ISO 3540x family require that simulation results be credible with respect to their intended use. This creates the need for methodologies that combine scalable virtual testing, structured credibility assessment, and realistic scenario generation from real-world data.

This paper presents a methodology for virtual validation and credibility assessment that combines distributed co-simulation with evidence-based scenario extraction. The approach is designed to support virtual testing and to align with future NCAP 2029 requirements. A central element of the methodology is the use of real-world field data as the basis for simulation scenarios. Instead of relying only on manually authored situations, the workflow extracts and structures relevant traffic scenes from recorded data and transfers them toward simulation-oriented representations.

For the on-highway case, a selected PandaSet highway sequence is used to demonstrate two complementary extraction paths from the same real-world source. In the first path, available ground truth (GT) information is used to derive a reference representation. In the second path, the same front-camera video is processed by an automated scenario extraction pipeline implemented in IAV Mela to obtain a second representation. The two outputs are then compared in a parameter-oriented manner with respect to actor identity, object class, image-space extent, ego-relative position, distance-related quantities, motion, orientation, and lane-level semantics. The comparison shows that exact numerical agreement is not expected, because the GT-derived reference is based on annotated 3D cuboid geometry, whereas the pipeline-extracted result is inferred from image-space observations and model-based scene interpretation. Nevertheless, the extracted result preserves the key scenario properties required for later simulation-oriented use. Fig. 1 illustrates the annotated-frame comparison between the GT-derived reference and the pipeline-extracted result for the selected on-highway case.

For the off-highway case, the paper presents a multi-layer fusion-based object detection workflow that combines conventional closed-set detection, open-vocabulary detection, and vision-capable large language models (VLLMs). In this workflow, VLLMs are used for semantic conflict resolution, false-positive verification, label refinement, and orientation-related scene understanding. The results show that the VLLM-supported workflow improves the semantic quality of extracted scenarios and supports richer downstream scenario generation in challenging off-highway environments. This complements the on-highway case by extending the methodology to environments in which semantic ambiguity and open-vocabulary perception are especially important.

Taken together, the presented methodology supports cost-efficient and trustworthy virtual validation by linking evidence-based scenario extraction with structured credibility assessment. The combined on-highway and off-highway examples show how real-world field data, advanced perception pipelines, and simulation-oriented processing can be integrated into a practical workflow for future AD/ADAS validation.

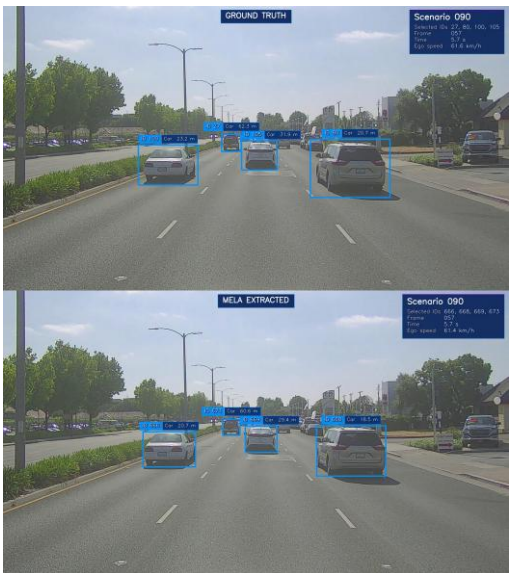

Fig. 1 GT-derived and pipeline-extracted annotated frames