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A Framework for Testing Driving Assistance Features with Electronic Horizon

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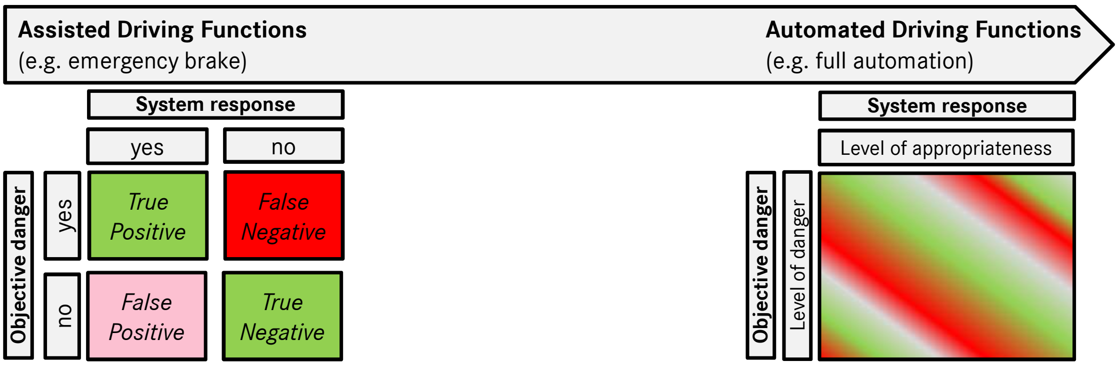
Motivation

- „***Testing*** *is the process of operating a system or component* ***under specified conditions****, observing or recording the* ***results*** *and making the results and making an* ***evaluation*** *of some aspect of the system or component"* *IEEE Standard Glossary of Software Engineering Terminology*



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Background

- **Traffic Sign Recognition:**
  - Enhancing the driver's awareness for important traffic signs in an automotive cockpit environment.
  - On-board forward looking camera system can detect variable speed limits as well as temporary speed limits at construction sites. However, it cannot detect implicit speed limits.
  - Combination of digital map and camera system can provide more accurate speed limit information.
  - Analysis and evaluation of distributed multisensor data fusion approaches using a Hardware-in-the-Loop co-simulation.

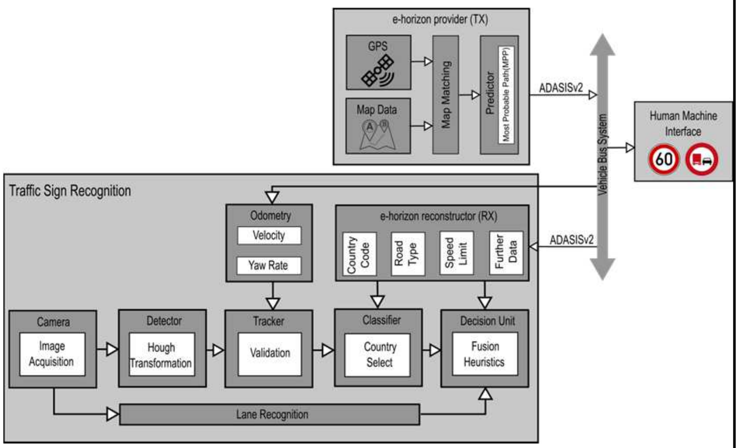

Figure 1. Decision-level fusion in the example of traffic sign recognition

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Background

- **Electronic Horizon Sensor:**
  - E-horzion serves as a predictive sensor to anticipate the driving path based on a non-physcial measuring principle.
  - E-horzion data contains vehicle position data as well as road segment attributes, such as road geometry, road class, speed limits, etc.
  - Up-to-date information about traffic, road condition are not provided by the mentioned e-horizon.
  - ADASIS protocol ensures a regular interaction between the ECUs which are generating or using the e-horizon.
  - The data of interest are either on the same path or on one of sub-paths ahead of the vehicle.

Table 1: List of message properties of the e-horizon-sensor

Message	Description
META-DATA	Semi-permanent data (e.g. country code)
POSITION	Vehicle positioning in the geo-coordinates
SEGMENT	Road ahead data (e.g. speed limits, tunnel)
STUB	Branch points (e.g. turn angle, intersection)
PROFILE SHORT	Road's course data (e.g. curvature, slope)
PROFILE LONG	Road specific data (e.g. longitude, latitude)

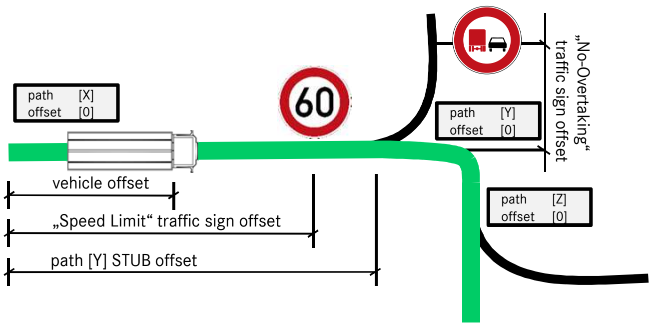

Figure 2. Positioning of entities according to the ADASISv2 protocol

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Research Questions

- **Electronic Horizon Sensor:**
  - Which environmental situations have to be recognised and interpreted at which level of percision and confidence of e-horizon sensor models?
  - Does the method of sensor fault injection provide stable and repeatable results?
  - Which evidence must be supplied for type certification so as to demonstrate safe and reliable performance?
  - Which methods must exist to reduce the testing efforts in the public space to a minimum and support sufficiently functional testing in virtual environments?

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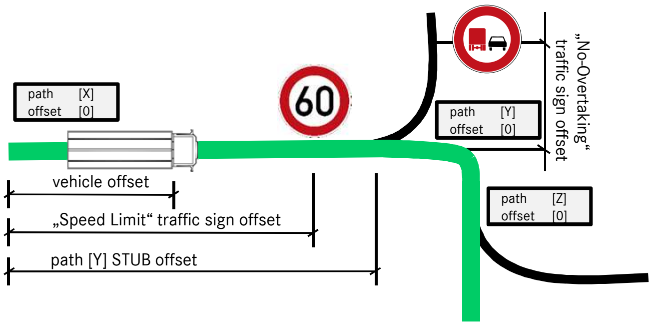

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Methods

- **Hardware-in-the-Loop Testing:**
  - Development of a generic and modular framework to study decision level fusion in a vehicle by driving simulation.

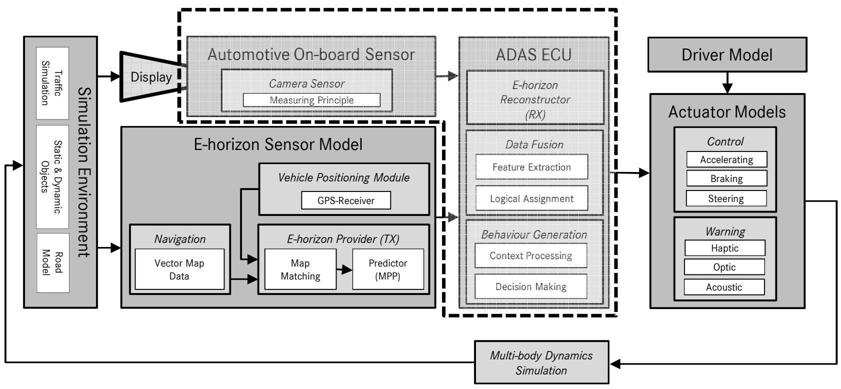

Figure 3. Schematic of the closed-loop driving simulation

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Methods

➢ Hardware-in-the-Loop Testing:

- ➢ Functional testing in a high-level sensor data fusion architecture for assisted vehicle guidance systems.
- ➢ Functional Mockup Interfaces (FMI) as well-defined in- and output interfaces.

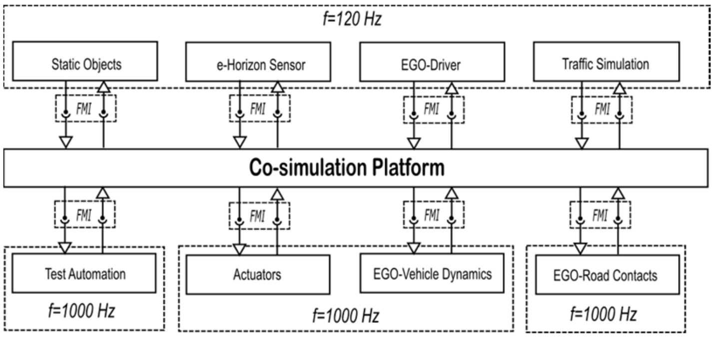

Figure 4. Integration of an e-horizon sensor into the closed-loop HiL co-simulation framework

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Results

➢ ADASISv2 message setup of the e-horizon sensor:

- ➢ The virtual map provides the test scenarios in which the ego-vehicle has his trajectory specified by the test case.

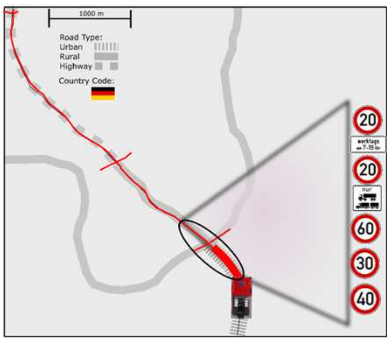

Figure 5. HiL test case with focus on speed limits

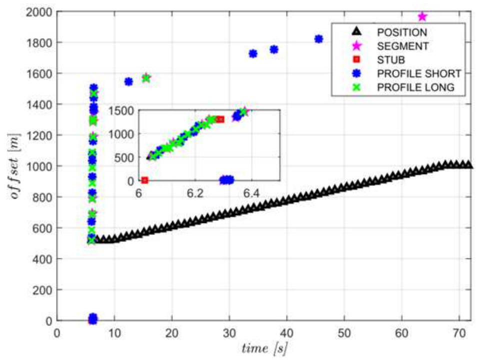

Figure 6. ADASISv2 messages with a preview length of 1000 m

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Results

- **Decision-Level Fusion:**
  - Synergistic use of physical environment data along with anticipatory map data.
  - The e-horizon and the camera system are fused to obtain the desired more accurate speed limit information.

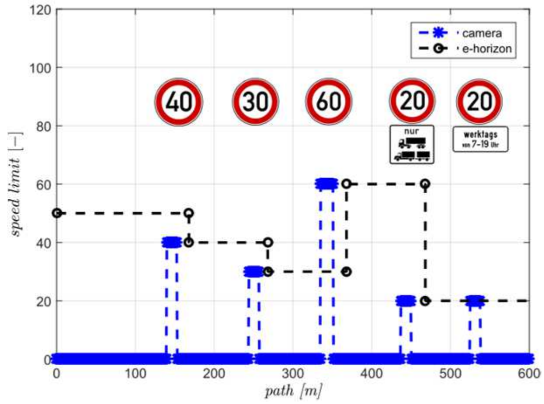

Figure 7. Fusion of camera control unit and simulated e-Horizon sensor

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Results

- **Sensor Fault Injection:**
  - A generic architecture of e-horizon sensor error injection for robustness testing of the System under Test(SuT).
  - Case studies regarding the effects of sensor error injection via driving simulation.

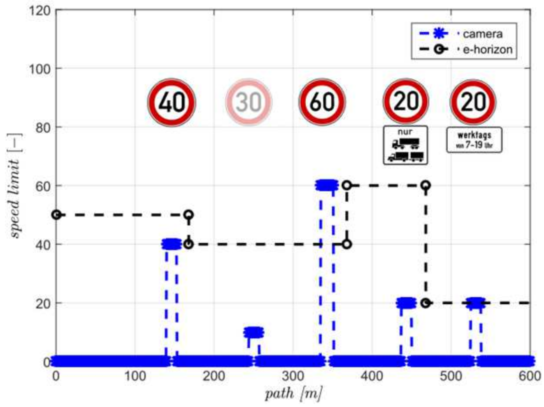

Figure 8. Omission of the speed limit from the perception of the e-horizon

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Results

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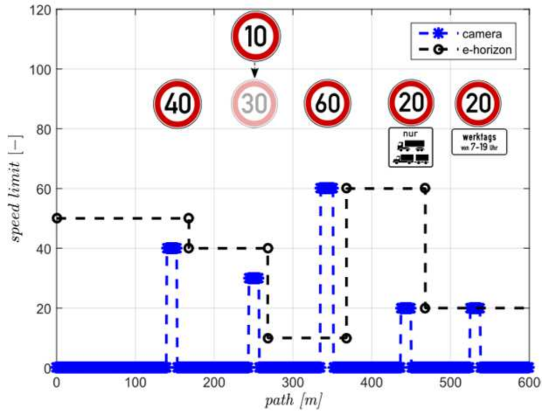

Figure 9. Replacement of the speed limits from the perception of the e-horizon

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Conclusion

- Analysis and evaluation of distributed multisensor data fusion approaches for intelligent transportation systems.
- Functional verification of multisensor fusion using a Hardware-in-the-Loop co-simulation.
- Application for co-simulation together with driving simulator, ADAS and sensor fusion.
- Integrating vehicle independent sources of information by extending the environment simulation.
- Case studies regarding the effects of sensor failures using driving simulation.
- The test system can be adaptable for Car2X functionality.

Thank you for listening!