

# Driver state estimation: from simulation to the real world

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## Introduction

The task of driving has become more complicated over the years. Advanced Driver Assistance Systems (ADAS) and in-vehicle information systems (IVIS) have introduced computer technology in cars. Despite the aim of a significant number of these systems to support drivers they can also increase the complexity of driving. Combining this with the fact that distraction plays a role in most (near) accidents [1], it is crucial to ensure that newly introduced systems do not add complexity nor increase distraction.

It is common to test the impact of systems on driver performance, distraction and cognitive workload, as a means to ensure that new (ADAS) systems do not overload nor distract drivers [2]. A driving simulator creates a controlled environment in which it is possible, besides being able to provide a reproducible driving scenario, to experiment with situations that are very rare (e.g. flooding of roads) or that are simply too dangerous (e.g. near-accidents) to study in the real world.

Conducting experiments in a simulated environment, like a driving simulator, is only of value if the measured effects can be transferred to the real world. A number of experiments have shown that driver behavior on the road is comparable to driver behavior in a driving simulator [3 - 5]. Although the results are similar, behavior is not identical. A careful experimental design can optimize the comparability of the behavior of a driver in the real and simulated world and therefore help to make the transfer from simulation to the road [5].

## ADVICE

The RAAK [6] project Advanced Driver Vehicle Interface in a Complex Environment (ADVICE [7]) focusses on the ability to assess driver state in real-time in the real world [8]. The project is a cooperation between HAN University of Applied Sciences – Automotive, Noldus Information Technology, TNO, TomTom and Delft University of Technology. Driver state has been defined as a combination of personal factors that affect driver performance. Examples of these factors are mental workload, fatigue, alertness, drowsiness, and driving skills. The Driver State Estimation (DSE)

developed in ADVICE has been evaluated in a series of real-world driving experiments, using a BMW equipped with behavioral measurement systems by Noldus IT and the HAN University of Applied Sciences. In order to assess the performance of the DSE a combination of driving performance parameters (e.g. steering reversal rate, headway), and driver state parameters (e.g. heart rate variability, pupil dilation) were selected and tested in a driving simulator in a set of driving conditions specifically designed to match the real-world testing environment.



Figure 1: Experimental BMW 'in action'.

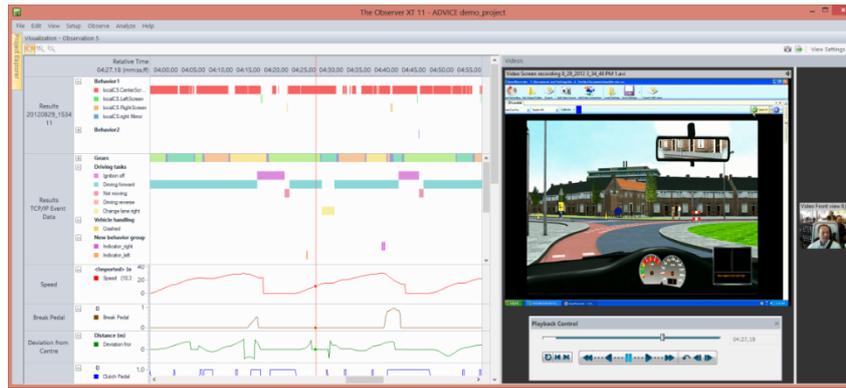


Figure 2: The Observer XT: integrated display of the driver's main front screen with gaze overlay, gaze events (red colored bars), driving tasks (multi-colored bars), and vehicle parameters (red/green/blue lines).

For the simulator experiments DriveLab was used. DriveLab is a novel, integrated system for the analysis of driver behavior, based on established proven technology from Green Dino, Noldus Information Technology and Smart Eye [9].

Based on the results of the simulator experiments the most sensitive parameters were selected for use in the real-world experiments. Also the experiments in the driving simulator and the real world have been designed to elicit identical driving behavior. This results in a set of parameters recorded, with the same equipment and in similar driving situations, in the real world and in the simulator. The results of both experiments will be compared and presented. Based on the results, a statement will be made on the suitability of the method of selecting real-world parameters based on simulator experiments.

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