Validation of Advanced Driver Assistance Systems with VEHIL

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1 Introduction to advanced driver assistance systems

With the increasing demand for safer passenger vehicles, the development of Advanced Driver Assistance Systems (ADASs) is of major interest to the automotive industry. State-of-the-art ADASs are adaptive cruise control and pre-crash sensing systems. They not only improve the driving comfort, but can also assist the driver in reacting to dangerous situations and collision avoidance.

The complexity of these intelligent vehicle control systems is however in contradiction to the increasing demand for reliability and safety. To improve fault management often redundant components and fault-tolerant controllers are implemented in ADASs. In practice, it is however difficult to choose the right measures and to validate their effectiveness. Currently, simulations and prototype test drives are used to validate an ADAS, but these tests can be unreliable and costly. An efficient methodology and new design tools are thus required for validation of the safety and reliability of an ADAS under the influence of a variety of faults.

2 Vehicle-hardware-in-the-loop testing

For this purpose TNO Automotive has developed VEHIL (VEhicle-Hardware-In-the-Loop), a test rig for intelligent vehicles [1]. VEHIL makes it possible to conduct hardware-in-the-loop experiments with full-scale intelligent vehicles in a laboratory environment. A virtual environment is defined in which the vehicles, the infrastructure and their interactions are simulated. The full-scale intelligent vehicle is placed on a chassis dynamometer that is interfaced with this virtual environment. Surrounding traffic participants are represented by autonomous robot vehicles (so-called moving bases) that carry out the relative motions to the intelligent vehicle. In this way the ADAS can be evaluated as if the vehicle is actually driving on the road, where the absolute velocity is removed from the test. A photo of the laboratory setup is shown in Figure 1.

3 Randomized algorithms for ADAS analysis

In VEHIL the control system can be validated with respect to environment sensor (radar) faults that can be introduced in a controlled way. It is however impossible to exhaustively test the ADAS for every fault type under every operating

Figure 1: Laboratory setup with intelligent vehicle (left), moving base (right) and chassis dynamometer.

condition. We propose a new methodology that provides a suitable test program in order to sufficiently (but also efficiently) cover the entire 'fault space' (the combined set of possible failure modes and complex operating conditions). For this purpose algorithms are developed, in order to construct an optimum set of VEHIL tests to sufficiently prove the reliability and safety of the ADAS.

This approach relies on randomized algorithms that form the basis for off-line Monte Carlo simulations with the ADAS control system. The strength of this approach is that the control system analysis does not depend on the level of complexity of the underlying system (in contrast to a deterministic approach). The disadvantage is that uncertainty is associated with the estimated level of reliability, since a random sample is chosen to represented the fault space.

When simulations have indicated the most critical scenarios (in terms of safety and reliability), a selection is made to be replayed in the VEHIL facility. With this practical evaluation the assessment can be made more reliable.

References

[1]   O.J. Gietelink, J. Ploeg, B. De Schutter, and M. Verhaegen. VEHIL: Test facility for fault management testing of advanced driver assistance systems. In *Proc. of the 10th World Congress on Intelligent Transport Systems and Services (ITS)*, Madrid, Spain, 2003. Paper 2639.