The Electric Vehicle That Plans Ahead

Assistance systems for an efficient use of energy in electric vehicles

As part of the joint project "Assistance systems for an efficient use of energy in electric vehicles", the Karlsruhe Institute of Technology (KIT), in cooperation with the German Federal Ministry for Education and Research, studied whether the energy efficiency of an electric vehicle can be increased by using detailed map data as a basis for the longitudinal control and the behavior of the vehicle. The joint project was part of the funding announcement "e-generation – key technologies for the next generation of electric vehicles " whose research aimed at abandoning the use of fossil fuels and studying electric mobility as a key technology. Not least, the objective was to establish Germany as a leading market for electric mobility as well as to form new partnerships between industry and science.

The objective of the project centered on the development of predictive measures geared to reduce the energy consumption of electric vehicles. In cooperation with Porsche, the project was carried out using a modified Boxster with an electric drive. However, the results were intended to be applicable to other electric vehicles as well.

In order to attain this goal, researchers at the Karlsruhe Institute of Technology (KIT) focused on the development of an autonomous longitudinal control. Simply put, at all times the optimal speed was to be set for the vehicle based on detailed route data. This support was supposed to be integrated into the vehicle as an intelligent adaptive cruise control (ACC). The driver was only required to steer and interfere if necessary. To be able to reach this objective, a variety of challenges needed to be met.

First, a functional concept was developed from which requirements were subsequently defined, and the behavior of the advanced driver assistance system was set to have three drive programs (sport, normal, range) as well as three operating modes (normal, guided, piloted).

Fig. 1: Displayed driving advice

The guided mode supports the driver with driving advice (on an optical and haptic level, e.g. via vibration of the accelerator pedal) in order to ensure a speed that is as appropriate as possible. This may also be adaptive: If the driver's reactions are repeatedly delayed, the driving advice will be displayed at an earlier time from then on. In piloted mode, the advanced driver assistance system takes over acceleration and deceleration and only displays corresponding advice which causes the vehicle to perform the respective action.

Subsequent to the definition of the drive programs and the operating modes, the software architecture and the interfaces between the individual software modules as well as links to other sub-projects were mapped out.

Overview

Customer

Karlsruhe Institute of Technology (KIT)

Country

Germany

Products

- CarMaker/HIL
- Xpack4 real-time computer

Challenge

Reducing consumption using advanced driver assistance systems

Solution

Assistance system for predictive longitudinal control

During the course of the project, a test environment was generated in order to test the developed function before its use in the real vehicle. The objective was to have the control units exhibit a behavior identical to their behavior in the real vehicle. The test environment comprised a prototype ECU which sent the commands for the longitudinal dynamics to the engine control unit of the test vehicle. In addition, the entire wiring of the hardware components (e.g. accelerator pedal, brake light switch, etc.) was laid out. In this case, the virtual vehicle was simulated with the open integration and test platform CarMaker by IPG Automotive. The operational design of CarMaker is modeled after real test driving. A virtual driver conducts predefined test drives on simulated roads that are based on real GPS data.

In terms of a validation environment, the researchers opted for a hardware-in-the-loop test bench by IPG Automotive (real-time computer in combination with control units) during the course of the project. Using this test bench, they were able to realize both the development of the energy-efficient driving function and its test. The researchers responsible for the project found that even a small real-time computer is of great use in the development of vehicle functions. Among other things, it allows new functions to be tested at a point in time at which real prototype vehicles are not yet available.

CarMaker ran on an Xpack4 real-time computer in this test environment.

Virtual test driving allows for reproducible and risk-free testing. Millions of kilometers may be driven in automated mode in a very short time. It thus becomes possible to analyze the effects of changes to the software or the parameters at low cost, efficiently, and without any danger to personnel, vehicles, or the proving ground. This approach allows for a drastic reduction of the number of prototypes required and massively shortens a vehicle's time to market.

Test procedure

In the course of the test case generation for the research project, a test catalog was compiled which comprised a total of approximately 90 different test cases.

For each known requirement for the system, a corresponding test case was generated which examined the respective requirement. Further test cases were generated by driving complex scenarios.

For this purpose, the virtual vehicle was driven on streets such as highways, rural roads or on inner-city streets that were modeled after real roads. These specific test cases offered the advantage of a combination of different input signals which realistically simulate real driving.

Conclusion

The HIL test bench helped the developers examine the operability of the desired function. During the course of the project, the software reached a maturity of such a high level that it enabled and significantly facilitated testing in the real vehicle. In subsequent tests in the real prototype, the focus shifted to the improvement of comfort.

The following milestones were reached using the open integration and test platform CarMaker as well as the real-time systems of IPG Automotive:

- The development of an assistance system for energy-efficient vehicle operation
- Use of the assistance system during guided and piloted driving
- Operating modes for the adaptation of the system's behavior to the driver's wishes
- Setup of a HIL test bench which enables the development and testing of the autonomous longitudinal control

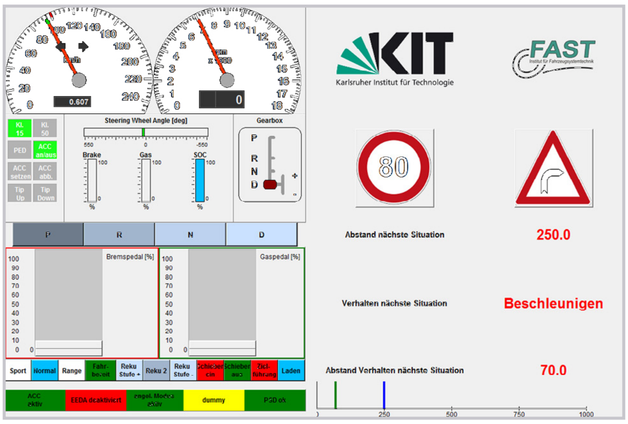

Fig. 2: Modified CarMaker Instruments GUI

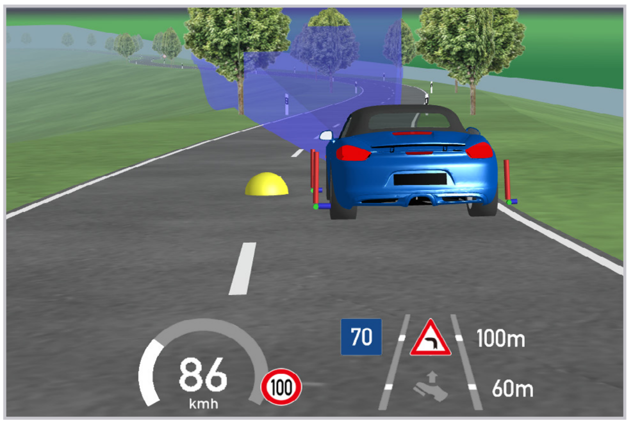

Fig. 3: Driving test scenarios