

Optimizing Driver Assistance Systems

Verification of Object Recognition Algorithms by Driver Assistance Systems



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ACC (Adaptive Cruise Control) systems monitor the corridor in front of a vehicle, detecting vehicles ahead and maintaining the distance to these vehicles desired by the driver. ACC systems also adjust the car's current speed to the traffic situation by automatically reducing engine torque, braking, and accelerating again, if necessary. To maintain the correct distance to the vehicle ahead at any speed, ACC systems require very complex and precise computing algorithms.

What sounds relatively simple is in reality a great challenge for the development engineers, because a driving situation that a human driver is able to evaluate effortlessly is a nearly endless array of numbers in an ACC ECU. A forward-looking radar unit supplies coordinates of objects in cartesian form, i.e. in the X direction (car's longitudinal axis) and Y direction (car's transverse axis), or as polar coordinates with vehicle distance and azimuth angle. From these, the ACC ECU concludes whether the distance to the car ahead is sufficient, whether braking needs to be initiated or whether it is possible to accelerate.

The evaluation electronics must also decide whether the acquired object should even be considered as a relevant control object, because the aperture angle of the radar sensors also detects any objects adjacent to the roadway. While radar scanning initially finds many objects, only the data of vehicles in one's own lane may be utilized for adaptive distance control.

This is not a trivial task, since information from the radar sensor system is not always clear and unambiguous. Some of the radar reflections are bumps in the road or simply false reports. This indicates just how important it is to conduct a check of the acquired data (signals) based on visible evidence (the video image). The reliability and operating safety of this system, with its acceleration and braking maneuvers, is in the truest sense a matter of life or death. Faulty behavior could lead to vehicle reactions that are incomprehensible to the driver.

For this reason, additional data are utilized at BMW to determine the exact distance between vehicles and exclude irrelevant objects. Besides dynamic driving data, data from GPS navigation are also used, for example.

Since there were no suitable products on the market, BMW initially supported the ACC development process by a tool it had written in-house, which helped engineers reach an objective assessment of the control algorithms. For production development, however, BMW is now increasingly relying on standard products that can also be used by its suppliers.

Tool-supported Evaluation of Sensor Data and Driving Impressions

Ever since the CANape Option “Advanced Multimedia” (AM) became available, BMW has been using this tool more intensively on projects and in production development. The tool’s standardized calibration protocols and flexible interfaces enable simple integration into an existing tool environment, leave room for engineering

extensions and offer maximum future compatibility, e.g. for obtaining objective test results to evaluate the assistance systems of suppliers.

Even the base version of the measurement, calibration and diagnostic tool CANape from Vector is able to record all ECU-internal data time synchronously (**Figure 1**):

- > Signals from CAN, LIN and FlexRay bus with the CCP/XCP calibration protocols
- > Peripheral measurement technology
- > Video and audio signals, and
- > GPS signals (optional).

To achieve optimal control functionality in the ECU, it is necessary to make numerous parameter modifications in an iterative process that can be performed online or offline with CANape. BMW utilizes the CANape Option “Advanced Multimedia”, an extension especially designed for developing driver assistance systems. A core element here is the Multimedia Engine, which displays ECU signals and information computed from them in 3D perspective in the video display. The relevant ACC coordinates can then be placed over the video image as defined bitmap information in 3D perspective (**Figure 2**). Only by means of such visual “matching” is it possible to objectively assess the original mass of numbers. The BMW developers no longer just get coordinate information on the positions of objects ahead of the driver; they can also immediately observe and verify them in a video image – from a bird’s eye perspective or side view. Thanks to the saved information, it is possible to study real driving situations – which are normally never one-hundred percent



Figure 1: Time-synchronous real-time acquisition and visualization of internal ECU signals via CCP/XCP, and of signals from CAN, LIN and FlexRay buses and external measurement equipment via CANape.

reproducible – in the laboratory and efficiently adapt the control algorithms.

Environment Detection with the Camera

A coordinate transformation is necessary to represent object data from the ECU as geometric objects in the Video Window. To calibrate the connected camera, all the BMW developers need to do is click eight reference points whose coordinates are known. Based on stored information, the tool automatically computes a coordinate transformation for each detected object – from global coordinates to image coordinates – and then displays the objects accordingly in the video image.

Vector also offers a suitable camera for the system, since BMW is not the only customer who values a universal and tested solution. ECU developers using CANape AM can use practically any desired camera, from a webcam to a professional high-tech device, provided that it has a USB or Firewire port and a DirectX interface. Optimal results are obtained with a camera that has a logarithmic characteristic and 120 dB dynamic range that further enhances image quality – both in tunnels and in direct sunlight. It is also possible to connect analog cameras via a Frame Grabber interface. Depending on the camera resolution, image refresh rate and number of cameras used, data might accumulate at rates of 20MByte/sec or more. That is why developers work with reduced image resolution; data compression units are also used to reduce the data volume.

A number of standard pixel graphics are provided for object representation in the video image. For example, a detected vehicle is represented by a rectangular frame, and other objects might be shown as an “X” or a line. In the process, it does not matter whether the ACC information is obtained from radar, infrared or ultrasonic sensors. It is also easy to assign signals to an object with the user-friendly GFX Editor for graphics (Figure 3). In another dialog

of the GFX Editor, the user defines the type of visualization for the specific object type. This involves defining any objects desired and linking them to the desired graphic symbols. In addition, users can also integrate their own graphics.

Joint advanced Development Work

For BMW, cooperative teamwork with the tool producer is a prerequisite for developing intelligent high-end systems. In this project, good cooperation has led to ideas that have spawned real functional extensions. For example, today – at the request of BMW developers – a so-called “driving tube” is generated with data from the ACC ECU; it is then represented in the video image as either a bird’s eye view or a 3D perspective. This driving tube corresponds to a virtual driving lane that demarcates the presumed future path. This defines the corridor ahead of the vehicle that is relevant for distance computation. Objects detected by the ACC system lying outside the driving tube do not need to be considered in distance control, and they are therefore represented by a different frame color. Also part of the evaluation is highlighting traffic signs and traffic lights. Theoretically, the tool can be used to represent up to 50 different objects simultaneously.

Similarly high requirements are placed on the hardware. The volume of accumulating data and enormous computational demands on the computing platform are still a great challenge. Previously, two PCs were needed to assure the specified performance. But this required manual data synchronization, since only one of the computers could access the internal ECU signals. Today, a dual-core computer platform is used for the ACC computations. Since parallel recording of multiple video sequences and processing of FlexRay data place increased demands on the CPU, BMW experts are seeking more balanced utilization of the two computing cores.

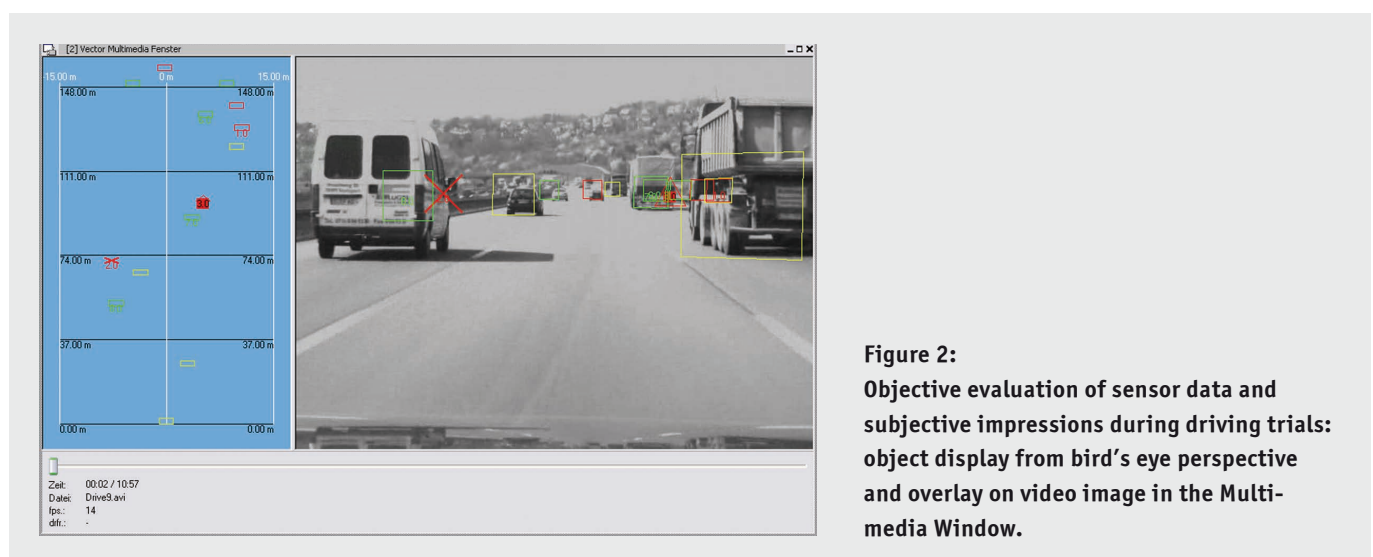


Figure 2: Objective evaluation of sensor data and subjective impressions during driving trials: object display from bird’s eye perspective and overlay on video image in the Multimedia Window.

Outlook

By visually comparing those objects detected by the ECU with the real environment, BMW developers now have an easy and efficient way to verify the object recognition algorithms of their ACC ECU. Cooperation between BMW and Vector is bearing further fruit, e.g. improved processor loading of dual-core and quad-core computing platforms in future CANape versions and functional extensions for developing parking assistance systems. In the next few years, safety systems will also be implemented based on environmental data acquisition. They require even higher levels of computing performance due to the need for comprehensive detection of the surroundings and networking of active safety systems to Adaptive Cruise Control sensors. CANape AM will also let BMW developers focus entirely on their core tasks in the future: considerable increases in driving convenience and further safety improvements in highway transportation.

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Figure, initial screen:
BMW Group

Links:

- [1] Homepage BMW Group: www.bmw.com
- [2] Homepage Vector: www.vector.com
- [3] Product Information CANape: www.vector.com/canape

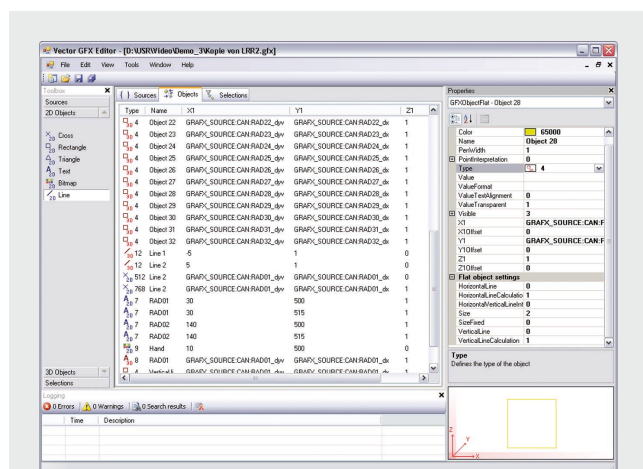


Figure 3:
Use of the GFX Editor for convenient object-signal mapping and grouping in displaying objects.

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