Generating stereo images for autonomous test drives with a stereo camera as the observer

3-D Car Spotting

Hitachi Automotive Systems has set up a development environment to comprehensively test a wide range of functions for autonomous driving. They pay particular attention to the driving functions that require a stereo camera to provide depth information. Virtual test drives are performed on a dSPACE simulator.

Thanks to their two lenses, stereo cameras can capture scenes as 3-D images, exactly like the human eye.

The development activities of Hitachi Automotive Systems in autonomous driving began in 1996, with an initial focus on functionalities such as autonomous emergency braking (AEB) and lane keeping systems (LKS). These activities were followed by applications such as autonomous lane changing and slow vehicle passing. Recent activities include a system called One Fail-Operational System: If an ECU for autonomous driving fails, the One Fail-Operational System technology transfers some functions to the microcontroller of other components, for example, the stereo camera, enabling the vehicle to temporarily continue to drive autonomously and safely. Real test drives were carried out regularly, on public roads and on mock-up city streets on special testing grounds. The tests on the mock-up city streets also examined aspects such as sensor fusion, i.e., the vehicle's ability to generate an overall picture of the traffic situation in real time by combining the data of the various sensors.

Mastering the Challenges of Autonomous Driving

For the development of functions for autonomous driving, it is crucial to test driving functions in combination with the associated sensors (camera, radar, etc.), not only on the road but also under realistic conditions in simulated traffic scenarios in the laboratory. This is absolutely necessary because it is not possible to carry out all relevant test drives on the road, as this would involve driving millions of kilometers with real vehicles to cover all traffic scenarios. Some tests would even be dangerous if performed with a real vehicle. The use of stereo cameras increases the complexity even further, because stereo vision is more complex than single-lens vision. To test stereo cameras, two images with a slight offset in perspective have to be calculated – one for the left lens and one for the right lens of the stereo camera. And above all looms the general demand for ever shorter development times and increasing development quality.

Advantages of Stereo Cameras

Stereo cameras have one decisive advantage over single-lens cameras: They can capture scenes as 3-D images with depth information, exactly like the human eye. With the help of suitable software, it is then possible to analyze the direction of movement of objects and to predict their movement for a few seconds. This way, stereo cameras can detect collision hazards and thus enable the vehicle to avoid the obstacle or brake in time.

Setup for Testing the Stereo Camera

The setup for testing a stereo camera (figure 1) consists of a dSPACE hardware-in-the-loop (HIL) simulator running the Automotive Simulation Models (ASM). The models simulate the overall traffic situation and generate images that are then fed directly into the stereo camera via an interface board, i.e., the images are not filmed by the camera but fed electronically into the electronics behind the lens. The left and right images are synchronized within microseconds using the shutter signal of the stereo camera. This accuracy is required to ensure that the stereo camera interprets the data as realistic information about a running traffic scenario. >>

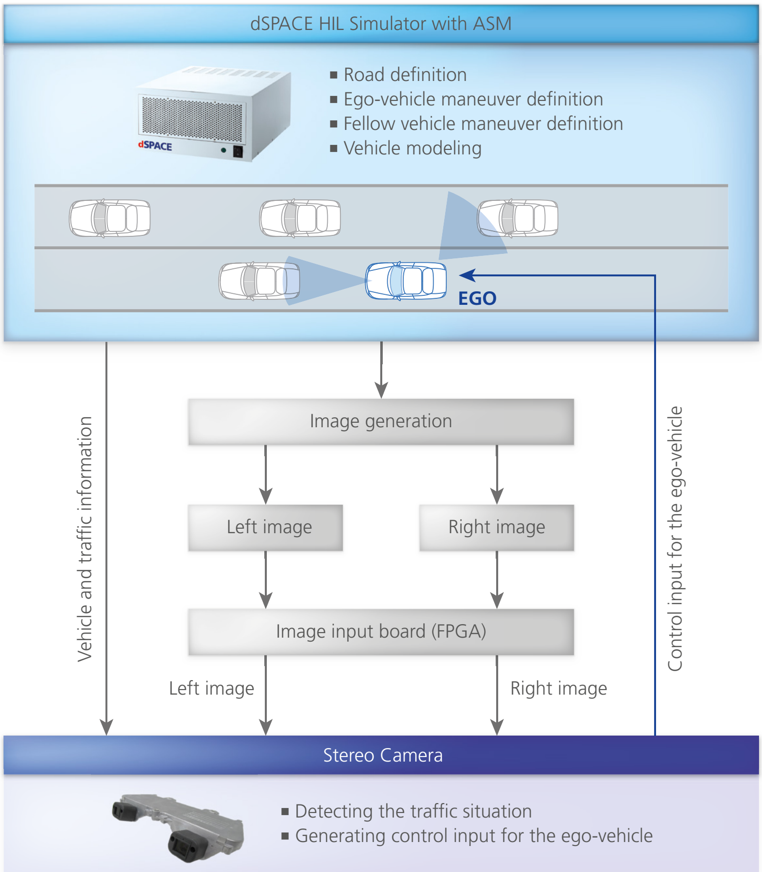

Figure 1: The setup for testing the stereo camera. It consists of a dSPACE simulator running a traffic scenario. The right and left images are created on the basis of this scenario and then fed into the stereo camera.

Setup of the Simulator for Autonomous Driving

To test the functionalities of the stereo camera in interaction with the other sensors in a realistic traffic situation, the test setup has been extended to a simulator for autonomous driving (figure 2). The central element of the setup is still the dSPACE simulator running the vehicle dynamics and traffic models of the ASM tool suite. This makes it possible to simulate a complete, realistic traffic situation with an ego-vehicle, including the sensors and the surrounding traffic. Hitachi Automotive Systems used ModelDesk to define and manage all parameters of the traffic scenario. Using the 3-D animation software MotionDesk, they visualized the traffic situations. This real-time 3-D animation gives users a clear understanding of the vehicle behavior during the driving maneuvers. With the experiment software ControlDesk, all data can be captured, recorded, and displayed in user-defined layouts, which can be set up using the comprehensive set of ControlDesk instruments. The sensor data generated in the simulator is transmitted to the real vehicle devices, i.e., the gateway and the ECU for autonomous

> "The seamless dSPACE tool chain offers the right tools for efficiently implementing our vision of an integrated simulation process for applications for autonomous driving."
>
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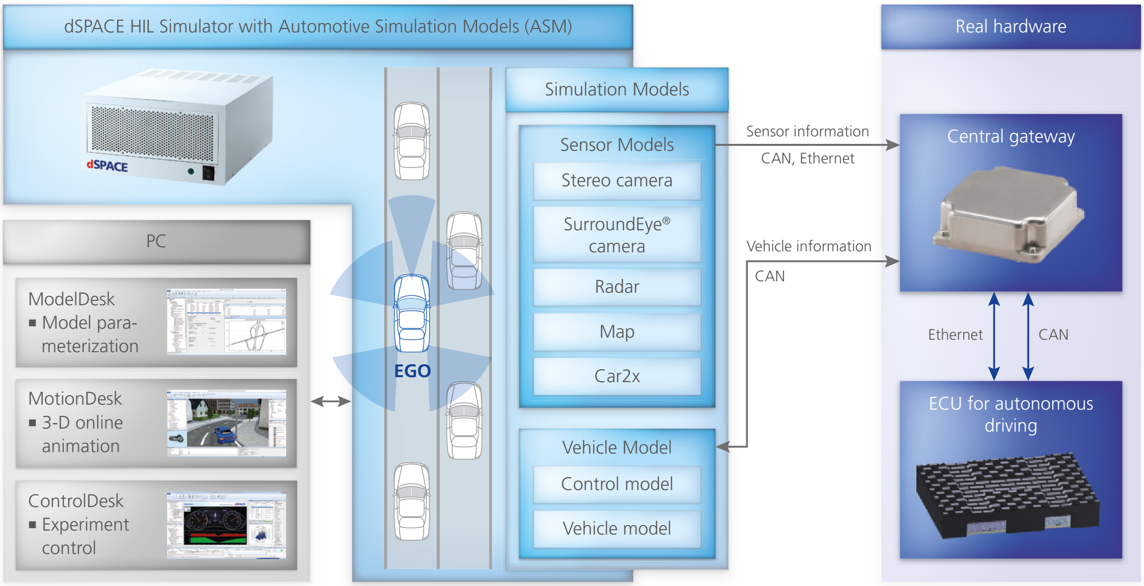

Figure 2: A traffic scenario created using the Automotive Simulation Models (ASM) is running on a dSPACE simulator. Based on this simulation, the real vehicle hardware makes its decisions, which are fed back into the dSPACE simulator.

> "The combination of a dSPACE HIL simulator and ASM makes it easy to create a detailed traffic scenario and test ECUs for autonomous driving."

Ryota Mita, Hitachi Automotive Systems

driving (AD). Via the gateway, the sensor data is fed into the AD ECU, which makes its decisions on the basis of the simulated scenario and produces instructions. The instructions are then fed back into the vehicle model in the simulator. With this setup, complex driving function can be tested and validated in the lab.

Vision for the Future

Hitachi Automotive Systems is already working on their vision for the future, namely an integrated simulation process from scenario generation to test automation to result analysis. This process will make it possible to create and execute multiple complex scenarios in a cloud environment in parallel and automatically. Another important aspect will be an advanced function for the analysis of simulation results. ■

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