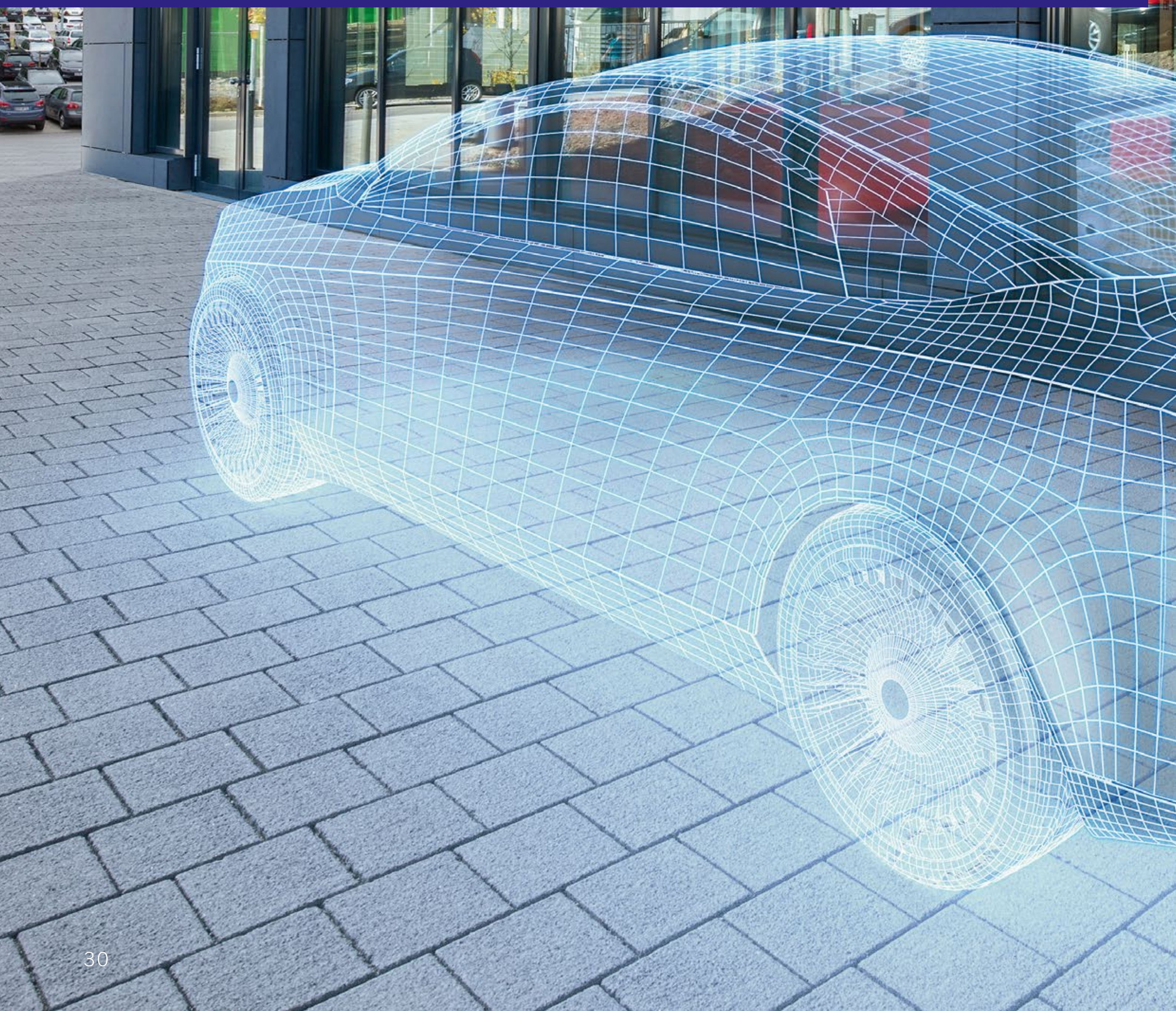
Virtual Reality as a Tool for the Development of Assistance Systems

Assistance systems have to be tested extensively. In an interdisciplinary project, Bertrandt creates a link between ADAS respectively IT connectivity to the backend for further development of adaptive cruise controls like a ACC. Extended ACC functionalities can be intensively evaluated in a VR environment with driving simulator.



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EXPANDING ACC SYSTEMS SMARTLY

Bertrandt has been working on internal innovation projects aimed at advancing new technologies for many years now. In the past two years, the fields of IT/connectivity and Advanced Driver Assistance Systems (ADAS) have been merged. Various showcases and use cases make it possible to focus on individual aspects of the overall context of Connected ADAS.

Under the name Intelligent Adaptive Cruise Control (iACC), a prototype in longitudinal vehicle guidance has been created by Bertrandt. The ADAS is derived from an Adaptive Cruise Control (ACC), which is already available as series equipment across all brands. This intelligent extension utilizes additional information to create a natural and safe speed control. First of all, quasi-steady state information is considered, which is commonly the case in systems currently on the market. One example is the reaction to a speed limit traffic sign. In addition, cornering control is implemented. For this purpose, during the simulated test drive the system makes use of information saved in a map.

Furthermore, the set vehicle speed can be influenced by the introduction of dynamic events. Examples currently implemented include events about persons driving on the wrong side of the road (wrong-way drivers), hazardous weather conditions (fog, icy roads), and construction zones, **FIGURE 1**. In each of these three events, the vehicle's speed is reduced in advance of the hazard in accordance with its severity, the driver's personal driving style, and the current vehicle speed. In addition, the driver is warned of the situation via Human-Machine Interface (HMI). To achieve a response, the necessary data must be reliably transferred to the vehicle while it is on the move.

FIGURE 1 shows the HMI when a driver is approaching a construction zone event in the simulation. The type of event is displayed as a warning in the HMI; also shown are the system activity (top center in green when the iACC system is active), the current speed (bottom left) and the speed that is controlled due to the hazard (top center). On the right, the distance from the event and the current speed limit are shown, too. The construction zone will therefore result in a reduction in speed to 80 km/h, even though there is no speed limit. The current speed is hence now being reduced.

COMPREHENSIVE VALIDATION NECESSARY

Putting such an ADAS onto the road requires comprehensive validation of its functions. Without this test effort, the risk of a fault in the system being undiscovered would be much too great. An untrained driver may be unable to cope with such a situation and would endanger the vehicle's occupants and other road users. For that reason, a test concept typically includes tests on different levels of abstraction that can be achieved consecutively in the development process. These levels range from software module tests, complete software tests (Software-in-the-Loop), and electronic control unit integration tests (Hardware-in-the-Loop) to complete vehicle experiments on a test track and under live conditions on public roads.

An additional aspect that must not be overlooked, especially in the case of new functionalities, is the early testing of the interaction between the driver or user and the system that has been developed. It is important to create an environment that is as realistic as possible for the test persons in order to reliably predict their subsequent reactions in road traffic. The earlier such feedback can be obtained from the users, the easier it will be to adapt the system behavior to achieve the highest level of acceptance for ADAS [1].

USING A VR ENVIRONMENT

One way of reducing the amount of effort involved in carrying out such studies is to use a Virtual Reality (VR) environment for a driving simulator. Such an environment was created for the iACC

FIGURE 1 Presentation of the situation when a driver is approaching a construction zone event; the type of event is displayed as a warning in the HMI (© Bertrandt)

system that was integrated into a fair demonstrator using a Unity engine at the 2017 IAA Frankfurt Motor Show. In addition to modeling the road and the vehicle, this simulator also contains dynamic elements in the vehicle's environment, such as weather phenomena or other road users. These components in the VR simulation can be placed on the route by the operator using a drag-and-drop function, thus allowing the uncomplicated reconfiguration of the scenario, **FIGURE 2**.

Using a VR headset, the test persons can freely look around the interior of the vehicle and over the steering wheel and interact with the vehicle by operating the pedals. In this way, their reaction to different situations can already be checked at an early stage and with little effort. The realistic representation of the situation and the consistent suppression of outside influences mean that the drivers become directly involved in the scenario and relatively quickly lose the feeling of being inside a simulation. This effect ensures that their reactions are close to their behavior in reality.

Such a simulation can be used to provoke safety-critical situations, such as accidents or emergency braking, that test the behavior of the system when pushed to its limits. What is more, even unusual situations that seldomly occur in reality can easily be created, like an iACC system reaction to a tight bend by reducing the speed, **FIGURE 3**.

Another conceivable scenario is assisting the driver in forming a rescue lane for emergency vehicles in a traffic jam. The instrument cluster will show to which side of the road the own car should move. The corresponding HMI concept comprises a functionality with or without warning signal as well as other supportive measures (interior lighting, volume of the audio system); it can be optimized on the basis of the driver's reactions.

In order to ensure that the ADAS can react to such dynamic events, its connectivity is absolutely essential. Possible scenarios are car-to-car communication over shorter distances or a centralized architecture with a backend server, a cloud and respective communication channels.

BACKEND SERVER-BASED VERSION

For the presented IAA showcase, the server-based version was chosen. All of the valid dynamic events are therefore available at all times in the cloud, and the different information sources can be connected. Services that provide weather information can give warnings about local severe weather conditions and a connection to police traffic reports can help to warn against wrong-way drivers. One extension that is currently being tested is the automatic detection of events using live data (for example, sensor data or anonymized driving behavior) transmitted from a vehicle fleet to the backend.

For the VR simulator, the mobile telecommunications network was initially used as a transmission medium between the backend and the virtual vehicle in order to take into account effects such as the relatively high latencies in communication. The data rates and network standards used can also be varied in this way. In the case of the iACC, dedicated hardware (the telematics unit or machine-to-machine gateway) is used for communication with the backend.

Of course, the mobile telecommunications network behaves differently in road traffic situations (loss of signal, handshakes between GSM, UMTS, LTE, etc.) than in a stationary simulator. Therefore, in the next step, the plan is to simulate the mobile telecommunications network itself, so that there is not only a focus on the experience of the simulated situation, but also a simulation of the behavior in the moving vehicle during particular events in the mobile telecommunications network.

DEGRADATION MECHANISMS AND DATA PROTECTION

In reality, a stable data connection with the necessary bandwidth cannot be guaranteed on every route. Therefore, methods to validate the transmission channel and degradation mechanisms are urgently required. For example, the Message Queuing Telemetry Transport (MQTT) protocol enables the use of a Quality of Service (QoS) level that offers a guarantee for the (potentially delayed) delivery of the messages sent. Together with a periodic heartbeat, the QoS makes it possible to easily create a system that can reliably detect interruptions in the data transmission and can react to them.

As far as degradation in such a situation is concerned, different approaches are conceivable. The system can operate normally for the period during which data on the route ahead has been transmitted. Only in the case of newly occurring hazards in this section will the system then not react predictively. If this risk is to be avoided, the longitudinal guidance system can also directly deactivate the intelligent predictive control system and inform the driver that this has happened. The selection of the suitable behavior will depend on the network quality, the driving style, and the traffic situation.

For the backend, the IAA showcase includes an IT architecture that can also be used for real vehicles. Data from the

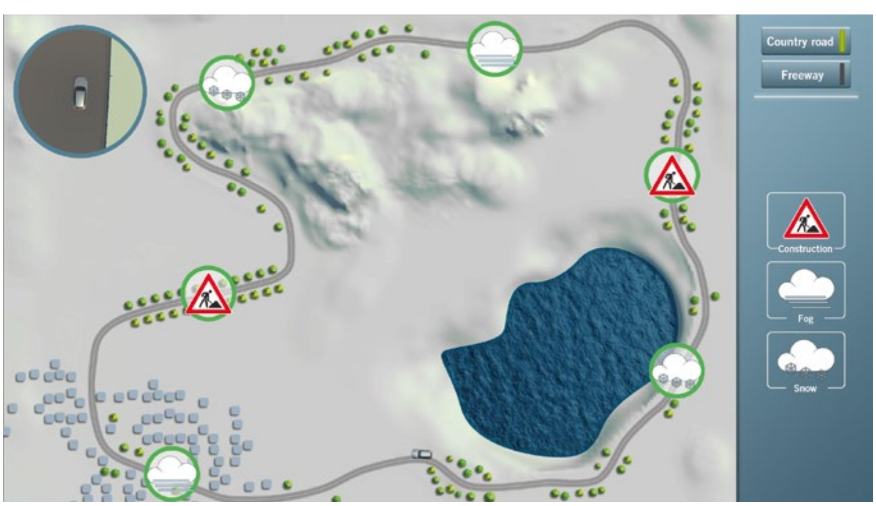

FIGURE 2 The driving simulator shows an overview map of a country road circuit: different events can be placed on the driver's route by using the drag-and-drop feature (© Bertrandt)

FIGURE 3 The driver is driving on the freeway; the iACC system reacts to a tight bend by reducing the speed (see speed display bottom left) (© Bertrandt)

driving simulator is received by an MQTT broker and made available again via the corresponding topics. At the same time, simulator data from the broker is sent to databases to enable the system to work with historical values and experiences. For example, the driving behavior of a certain driving style can be compared with older recordings in order to make better predictions for the current situation and also to recognize gradual changes in the driving style. The technology used to store the data is based on the required performance, and is freely scalable as required. Furthermore, an analytics platform is connected directly to the broker to ensure that data can be processed as quickly as possible and recommendations for action can be derived from this.

As soon as recommendations have been generated in the backend by analysis algorithms, these have to be made available to the vehicles concerned or to the simulator. For this purpose, a method was developed to provide information that is targeted specifically at vehicles. To do this, the world is divided into regions. For each region, an MQTT topic is created in which all relevant information and results of the analysis algorithms are published.

For data protection reasons and to minimize server processing requirements, the different vehicles are not allocated to the corresponding channels by the backend. Instead, each communication participant subscribes to relevant topics on the basis of geographic coordinates and will therefore receive only the information that is needed. This effectively avoids unnecessary data traffic.

Regardless of whether the vehicle is in the real world or a virtual world, its position determines which topic it subscribes to. If the information includes a hazard (black ice, fog, wrong-way driver, etc.) that is defined in the simulator, the situation can be directly experienced and the ADAS can be tested as a prototype.

With the experience gained from the IAA fair demonstrator and from extensive in-house testing, the iACC system is currently being expanded with the addition of new functionalities. For example, the driver is supported in creating a rescue lane for emergency vehicles, which also involves upgrading the HMI. Work is also being done on the real-time-capable analysis of data in the backend, which will in the future detect additional event classes and will be able to offer an even higher level of reliability for the results.

REFERENCE

[1] Haböck, U.; Schwenninger, J.; Redepenning, A.; Buchner, C.: Human-centred Engineering. Future of the Technology Industry. In: ATZworldwide 119 (2017), No. 4, pp. 44-47