Designing the Human Machine Interface of Innovative Emergency Handling Systems in Cars

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PROBLEMS OF THE HMI DESIGN

In the European Transport Telematics project SAVE, a "system for the effective assessment of the driver state control and vehicle control in emergency situations" is being developed. Components of this type of innovative emergency handling systems are under development since several years including especially driver monitoring and warning (Brookhuis 1991, Kaneda 1994, Katahara 1995, Wierwille W.W. 1993, 1994), and automatic driving capabilities (Carrera 1995, Naab 1995). The human machine interface (HMI) of the integrated systems are related with specific and partly new problems concerning traffic safety on the one hand and the engineering process in the development on the other hand.

Concerning traffic safety it can be said that the human machine interface (HMI) of such type of systems is unobtrusive under normal driving conditions. There is no necessity for any human machine dialogue. The system can be easily activated together with the engine. The driver state control subsystem and the related routines will run in the background. The driver will not be aware of the system under normal driving conditions. Only if an impaired driver state is detected by the driver monitoring system a human machine interaction might be required. In this case the boundary conditions for the dialogue are worst. The driver is in an impaired state and her/his performance is most probably restricted, both for the interaction with the emergency handling system and for driving. The ability to drive safely is therefore decreased. The driver should thus concentrate on the basic driving functions and on the traffic situation. But in addition the human machine dialogue is required, which again may effect traffic safety negatively. This means that there might be the risk that those innovative systems can be counterproductive in certain situations.
To go more into detail five different principle cases and related problems can be distinguished:

1. Normal driving conditions do not require any human machine dialogue. There will be some basic system state information displayed for the driver, which needs not to be read regularly.

2. There is an emergency detected by the emergency system in the surrounding traffic via car-to-car communication. Then the driver is not in an impaired state and therefore able to perform in an appropriate way. But if the emergency in surrounding traffic is located nearby ahead the driver has to turn attention to the traffic situation. There is a risk that a warning message by the system might distract the drivers attention from the road scene.

3. The driver monitoring system detects an impaired but non-critical driver state. Then the system has to warn the driver and make her/him to react properly. There might be also a high information flow to the driver under adverse conditions.

4. The driver monitoring system detects an uncertain driver state. This is the most critical phase for the human machine interaction. The system has to decide quickly by communication with the driver whether to take control over the car or to leave the control to the driver. Therefore there is not only an information output to the driver required, which needs to be understood but also a driver reaction. This means an information input by the driver to the system, which she/he might have never performed before and all this in a probably critical personal situation of the driver and an evolving critical traffic situation.

5. The driver monitoring system detects a critical driver state. Then the automatic emergency handling functions will be initiated, e. g. an emergency call will be sent to an emergency centre and the car will be stopped automatically. This situation is highly demanding for the technical systems but it is less critical for the influence of the HMI design on driving safety as the driver is suspended from driving.

Besides traffic safety considerations the design process itself is an important issue. The HMI as a safety relevant subsystem has to be considered early in the design process. HMI concepts have to be evaluated by users as soon as possible in order to deliver relevant input for further design decisions for the whole system. The HMI has to be developed in parallel with the development of the new system technologies for driver monitoring, automatic emergency handling and communication. This results in uncertainty concerning the design of other technical
subsystems, which means that the HMI design has to start on the basis of assumptions. This means simultaneous engineering is in demand and rapid prototyping methods are required.

**APPROACH FOR THE HMI DESIGN**

Figure 1 shows the basic approach chosen for the design of the HMI of the SAVE system.

**Figure 1: Design process for the HMI of the SAVE system**

As a basis for the definition of the HMI, design principles are formulated, in order to help the HMI designers of the SAVE device. They show the basic philosophy of the interface design rather than pre-setting design decisions. The design principles are based on general principles.
of the design of HMIs in vehicles. They take the basic functions and objectives of the SAVE device into consideration.

SAVE HMI scenarios are developed in order to achieve a common understanding of the HMI within the project teams in an early phase of the project. External factors and developments, e.g. market trends in car design and available telematic infrastructures are considered as well as internal factors, which are related to further results of the SAVE project to form scenarios of boundary conditions of the HMI design. Those environmental scenarios are used to form basic scenarios of the key design characteristics of the HMI. Scenarios are pre-selected by the consortium for further elaboration of the corresponding HMI design.

In the next steps a functional specification is performed. The results are used as input for the conceptualisation of the HMI design. First drafts are visualised on paper as well as with a rapid prototyping tool. This tool is also used to create computer simulation of alternative design concepts, allowing for demonstration as well as for user tests of the human-machine interaction under non-driving conditions. The pointing device of the computer is used during those user tests. User acceptance of concepts and some aspects of the user dialogue can be tested. As the manipulation and spatial arrangement of displays and controls is not realistic, further user tests are required.

For this purpose a mock-up of one of the selected alternatives is built first and then integrated in driving simulators for further testing. Driving simulators can offer a realistic driving task and realistic spatial arrangement and manipulation of displays and controls. This is necessary to test anthropometric and biomechanic aspects of the design. Even more important is the test of the interaction of the primary driving task and the dialogue between the the driver and the emergency handling system. Those simulator tests provide answers to crucial design questions related essentially to traffic safety.

But also driving simulators cannot give all final answers. Driving dynamics simulation is mostly missing in the simulators and in other cases it is poor. Also the perceptual situation is not realistic in the simulator cabin. Because of the darkened cockpits perceptual ergonomics aspects cannot be investigated.
Thus the adjusted HMI design has to be implemented in a demonstrator car, allowing for testing of the functions of the integrated system under full driving conditions, gaining the required insight for the last HMI design adjustments.

RESULTS AND EXPERIENCES

The integrated simultaneous engineering and rapid prototyping approach using product scenarios as well as computer demonstration/simulation of the HMI has proven to be useful so far for the development of the in-car HMI of innovative emergency handling systems for passenger cars.

Figure 2: HMI demonstrator, accessible on the WWW

The applied scenario technique allows for the functional specification and conceptualisation of the HMI, when important technical decisions are still to be taken. Computer simulation of the HMI with the rapid prototyping tool ALTIA provides demonstrations and facilities for user tests in an early phase of the development process. The ALTIA demonstrator
simulator has even been made accessible online via a WWW site and could be used by project partners for expert evaluations (figure 2). Both, expert and user tests were performed in order to analyse the deficits of alternative HMI design concepts.

The user tests and expert evaluations with the ALTIA simulation revealed weak points of the concept and resulted in an appropriate feedback for the optimisation of the concepts and valuable input for future design steps. The critical issues mentioned at the outset of the paper cannot be clarified with those computer simulations. Driving simulator tests are required to evaluate the design according to traffic safety aspects.

RÉFÉREnces


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