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Project Title	DISC - Driver interaction with Safety Scales and Scoring Systems based on different use case scenarios
Coordinator	*University of Skövde*
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Project Duration	2022-11-01 – 2023-08-31
Confidentiality	SAFER Partners only

Contents

Summary

This pre-study project is to create a basis for traffic safety information to be used in developed interaction with drivers in different use case traffic situations. The central question is the potential role that safety information (safety score?) can have in interaction with car drivers. Safety information will include data from external and driver data in order to be trustfully relevant for human drivers and autonomous vehicles. The project will create a scientific survey of the basis for traffic safety information and scores and possible different reactions from different drivers based on gender and possibly age and culture.

The pre-study project will use workshops to develop the basis for use case simulations from obtained real data where the simulations can then be tested in a driving simulation environment. This will also include the role that human cognition plays in understanding different traffic situations to avoid potential limitations of computational models. The central goal of this pre-study project is to develop the scientific basis for a larger project application in FFI-Vinnova that will specify driver monitoring in relation driver interaction with safety information. This pre-study project will also include OEMs in discussions and workshops.

A literature survey of the factors of safety information was used to determine the limitations and improvements to inform drivers about traffic safety conditions that are important for drivers (e.g., Seppelt & Lee, 2019; Harms et al., 2020; Schwall et al., 2020; Mahmoud et al., 2022 (research at University of Skövde)). This information will then be used in future project(s) to also evaluate driver interaction and trust from a gender perspective (Son et al., 2015). Autoliv, Smart Eye, and Viscando are also partners in this project. Their contributions were the data sources and the current connections to driver behavior that is needed for the development of computational interaction models. Use case simulations from obtained real data were also studied to construct the simulations that could then be tested in a driving simulation environment. Experiments were conducted by students in their final year project within the User Experience Design education program at the University of Skövde. This was also in collaboration with Autoliv.

DISC - Driver interaction with Safety Scales and Scoring Systems based on different use case scenarios

1. Background

The safety concept has been previously developed and evaluated according to different traffic situations and how safety information can reliably inform drivers about different critical factors and risks in traffic. Our pre-study has used Hollnagel et al. (2015), Aven (2022), and Schöner et al. (2021) as important references for the concept and computation of safety scores. The different kinds of safety according to these authors provide a basis for constructing more flexible safety scores. A recent article in The Guardian (Clarke, L. (March 27, 2022)) addressed the issue of how self-driving cars got stuck in the slow lane. One critical issue is the lack of AI systems to do what humans do, namely, to generalize from one scenario to the next. This is also stated as a problem with no solution for AI systems. The other major issue is the ability to handle rare traffic cases. Philip Koopman was one of the experts in the article, and he also has a recent publication, A Safety Standard Approach for Fully Autonomous Vehicles, (Koopman et al., 2019). One of the key topics that must be addressed is the needed development of the ADAS driver interaction level safety metrics, which is what this pre-study project will work on to create a specific and larger innovation research project.

2. Project set up

2.1 Purpose

In a selected use case, the project examined the factors that significantly contribute to the interaction between information about a traffic safety level and driver behavior from an overall and gender perspective since there may be clear differences that determine how and/or what information is presented to drivers. The example of possible gender differences may in fact create different situations for the role of safety information and for the level of trust in relation to the interaction with the safety information and scores. This could be a very important factor for traffic sustainability. To what extent should the safety information reflect driver behavior according to gender differences?

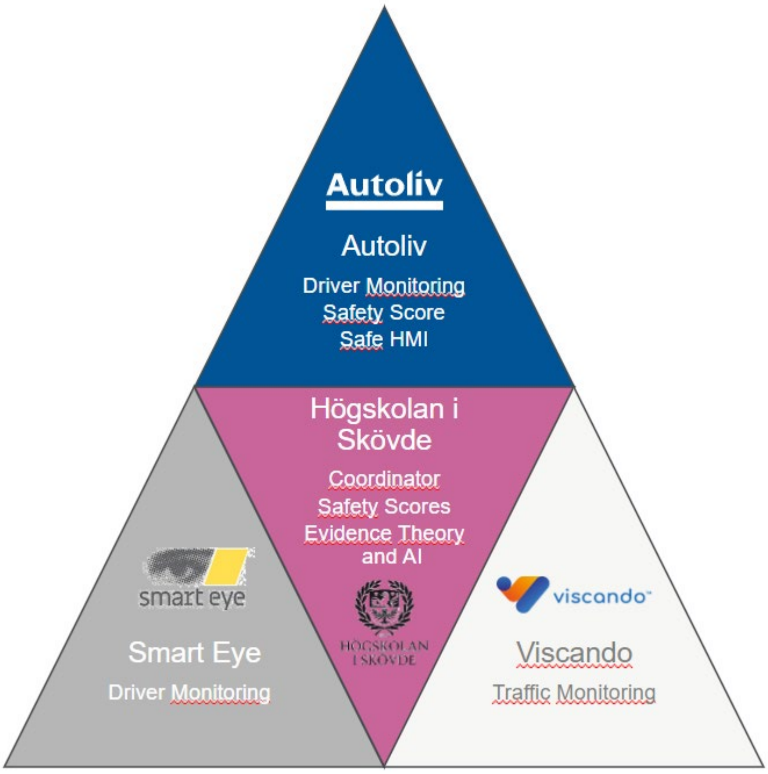
This includes a clear connection to the area of Explainable AI (XAI) that has emerged in the intersection of AI and HCI. Several reviews in the area provide good overviews of the various XAI methods, concepts, and use. However, the scenario and requirements on autonomous or semi-autonomous driving systems are far from the classical applications of XAI. A possible key factor then has to do with the computation and display of the safety information where a possible safety score could be used. The interaction between computational methodology for safety scores and driver behavior is an area of important development for driver behavior in relation to different levels of autonomy. This is not just a computational issue but also an ethical and sustainability issue.

2.2 Objectives

- We can evaluate different ways to act in the traffic situation and decide upon how to progress safe and efficiently the interaction between information and driver understanding.
- Define and measure user experience indicators related to safety.
- Identified critical use cases, e.g. driving a heavy truck in fog among vulnerable road users.
- Prediction of future safety critical scenarios, automation included.

2.3 Project period: 2022-11-01 – 2023-08-31

2.4 Partners



3. Method and activities

Three different methods and activities were used:

1. Workshop discussions
2. Contributions from the different project partners
3. Experimental testing using simulations

The pre-study project used workshops to develop the basis for use case simulations from obtained real data where the simulations could then be tested in a driving

simulation environment. This included the role that human cognition plays in understanding different traffic situations to avoid potential limitations of computational models. This pre-study project included contact with Scania in discussions and workshops.

4. Results and Deliverables

The contributions from the different project partners (Autoliv, Smart Eye, Viscando) are a basis for developing the safety intelligence of driver support systems in HMI.
Clear results from our pre-study are the necessary data interactions (information fusion) between **four** main areas (**Figure 1**):

1. **traffic infrastructures**,
2. **external traffic interaction for vehicles and other road users**
3. **internal vehicle behavior**
4. **the development of driver monitoring for the driver understanding of the current and potential traffic situations**.

The interaction between these main areas is necessary to develop the levels of safety and autonomy for driver support systems. Driver behavior and interaction with driver support systems depend on "early" collaboration between algorithm development and human understanding of the purpose of safety level information and potential behavior. An example of this are the results from our previous simulator studies (Thill et al., 2018; Thill et al., 2014) where trust for a driver support system is increased if the system can provide data and a reason for the suggested behavior, and the driver realizes that the system has sufficient information about the traffic situation.

A further finding in our pre-study is the need for the development of data from connected vehicles (Ahmed et al., 2022). This kind of connected data will provide even more information about the potential vehicle interactions in different traffic situations. It will also increase the level of safety for driver support systems and interaction with drivers. Connected vehicle data can also be used to avoid limited operational design domains (ODDs) that have been used as a basis for use-case scenarios.

In interactions with AI systems, anticipation (predictive processing) is essential. This is also a clear case for the future development of autonomous vehicles and in relation to driver behavior and monitoring (Mahmoud et al., 2022 (University of Skövde); Engström et al., 2018). From a computational model perspective, this includes different levels and interactions. Neural networks, deep reinforcement learning, and symbolic AI can provide low-level data implementations and high-level symbolic and rule-based implementations. The key finding is to use what is also referred to as intention prediction (anticipation and predictive processing) to create a much more adaptive interaction between driver support systems and driver decision behavior.

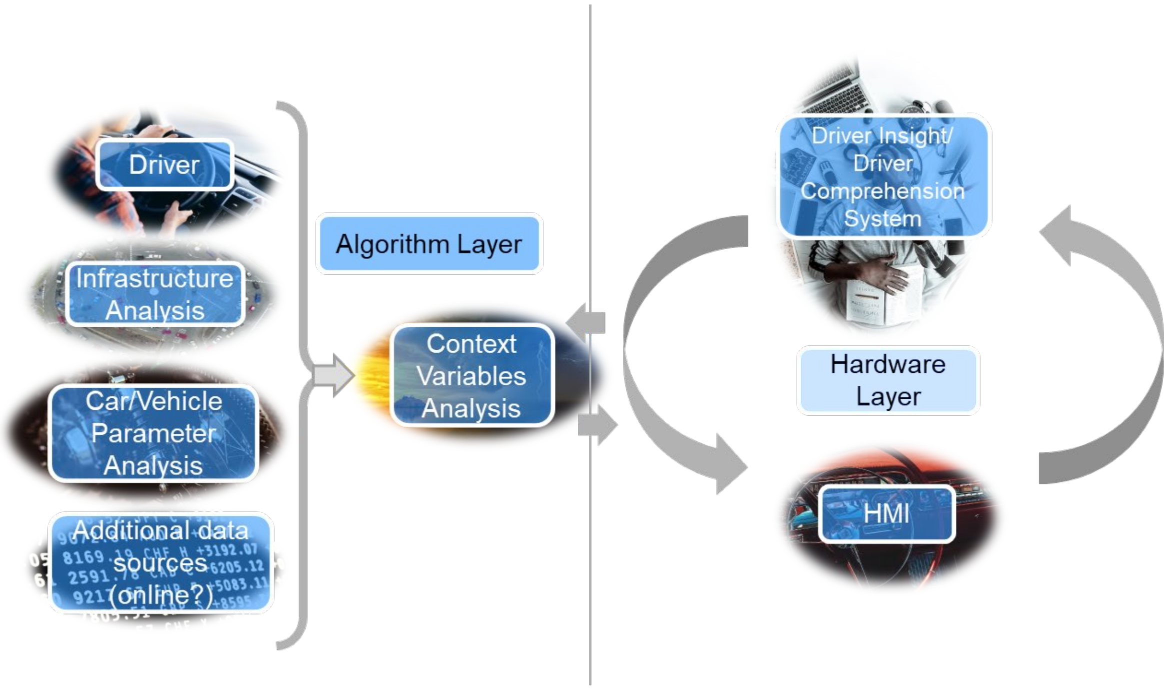


Figure 1. The interaction between different data sources and traffic situations that need to be used for ADAS-driver interaction.

We regard the task to establish a safety score of the situation to be an information fusion task. Where we describe information fusion as a research field that develops, deploys, and tests methods and techniques usable for the automatic or semi-automatic combination of data and information provided by different sources (see for example Steinhauer & Karlsson (2019)). The purpose of information fusion is to fuse the data and information into a coherent representation of the information. This is based on the idea that we usually can make better decisions given more information. While this is not necessarily always true, e.g., when information is conflicting, contradictory, deceiving, or very uncertain, it is generally a reasonable approach to consider all available information before concluding. Information fusion also allows us to infer (make explicit) new information from data that we did not know beforehand. Furthermore, the study of information fusion teaches us about uncertainty management methods with that the uncertainty within information can be handled appropriately when the information is fused. The methods studied within information fusion can stem from any other research area, such as mathematics, statistics, artificial intelligence, machine learning, optimization theory, etc. For any specific information fusion tasks, the best methods are chosen, adapted, and combined.

The Real-Time Safety Score can be used in several ways:
Driver Feedback:
The most immediate use of the RTSS is to provide drivers with feedback on their behavior and the safety of their current driving conditions. For example, if a driver is

following too closely to the vehicle in front, the RTSS could decrease, and the driver could receive a warning or suggestion to increase their following distance.

Safety Improvement:

Over time, drivers can use their RTSS to identify patterns in their driving that are unsafe and work to improve their habits. This could lead to safer driving overall and a reduction in accidents.

Insurance Pricing:

Insurance companies could use the RTSS as a factor in pricing their auto insurance policies. Safer drivers, as evidenced by a higher RTSS, could receive lower rates.

Fleet Management:

For companies that manage fleets of vehicles, the RTSS can provide a way to monitor the safety of their fleet in real-time. They could identify drivers or vehicles that are consistently unsafe and take corrective action.

Autonomous operation:

The RTSS could serve to evaluate the safety of their vehicles under different conditions, providing valuable data to guide the handling of the vehicle in real time.

The Real-Time Safety Score provides a quantitative measure of safety that promotes safer driving habits for both manual and autonomous driving, provides valuable feedback for drivers and fleet managers, and contributes to the development of safer vehicles and roadways.

Two experiments were also conducted to test potential differences between different perceptual warnings for drivers. The experiments were conducted by four final year students within the User Experience Education Program. Paul Hemeren was their supervisor.

This first experiment collaborated with Autoliv to experimentally test different combinations of haptic information as an interaction with drivers. Here is the abstract of the article and the link to the complete article. It is important to emphasize that even though the results were not significant, there was a clear pattern that suggests an effect of haptic information. There were only 10 participants in each of the four conditions, which was the most that could be used given the time frame for the project.

Title: Haptic feedback in seatbelt and its effect on the driver's reaction time to frontal collision warnings (FCW) in semi-autonomous vehicles

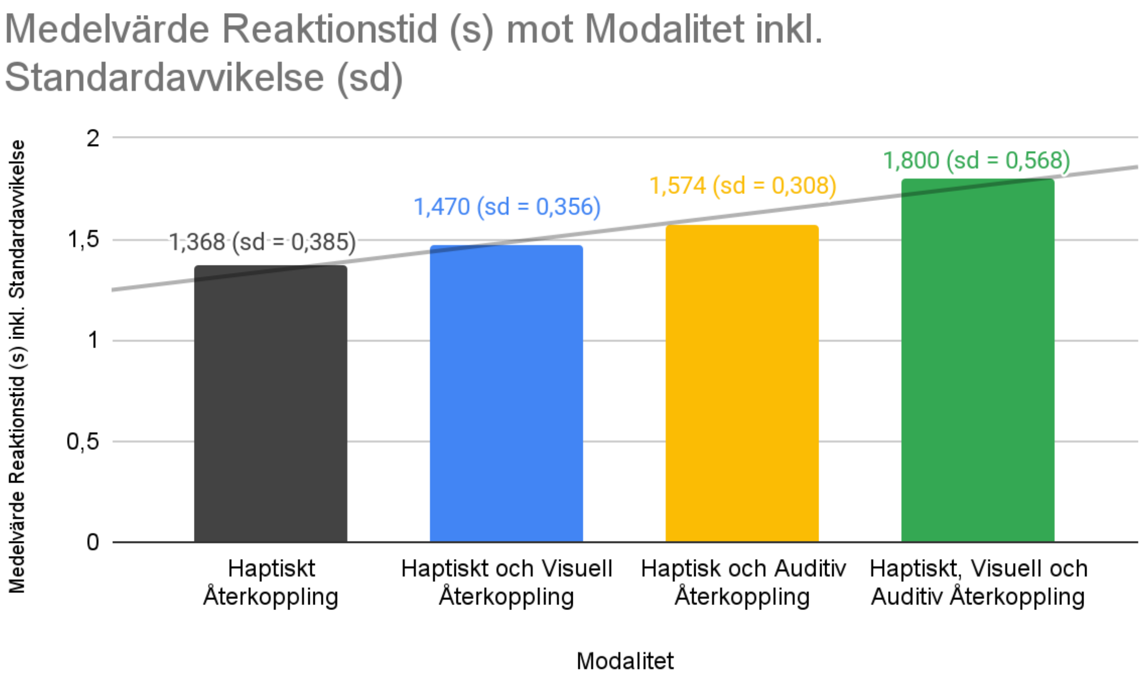
Authors: Julia Mattsson and Edin Pilipovic

As vehicles become increasingly automated, it is important to have a functioning collaboration between the driver and the autonomous vehicle. In the case of semi-autonomous vehicles, the driver is not completely disengaged but still bears responsibility for driving. Since only certain functions are automated, the vehicle needs to be able to give the driver clear feedback about the current driving situation and prompt the driver when he or she needs to resume control of the driving again.

One such type of feedback is anti-collision warning systems, where the vehicle emits warnings to prompt the driver to act and avoid an accident. Such type of warning can be of haptic, visual or auditory modality. Previous studies show that there are several advantages to using haptic feedback. This study describes, based on retrieved literature and a participant survey in a driving simulator, the effect of haptic feedback on the driver's reaction time in frontal collision warnings. It is tested as its own modality as well as in combinations with visual and auditory feedback.

The result shows that the driver's reaction time is shortest when warning with haptic feedback as its own modality. However, the results were not significant, as the difference in the mean values between the groups was not large enough to be generalizable. It is deemed important to further study in future investigations how haptic feedback affects the driver's reaction time, as a separate modality as well as in combination with visual and auditory feedback, in semi-autonomous vehicles.

Link to the final year student project in Swedish: https://www.diva-portal.org/smash/record.jsf?pid=diva2%3A1773990&dswid=-8476



This second experiment investigated potential gender differences in relation to female and male voice assistants.

Title: Voice Assistants Type of Voice in Autonomous Vehicles and Its Impact on Trust and Situation Awareness
Authors: Frida Karlsson and Jennifer Andersson

This study aims to investigate whether a feminine or masculine voice in voice assistants affects drivers' situational awareness and perceived trust in autonomous vehicles. An experimental study was conducted in order to investigate this, where participants were situated in a simulator of an autonomous vehicle that simulated driving scenarios. The participants were divided into two groups where each group experienced one of two types of voice assistants, either with a feminine or a masculine voice. The participants had to experience driving scenarios where warning situations of varying degrees of severity arose, where they had to make decisions about how they would have handled the situation. In connection with the driving scenarios, three types of data collections consisting of interviews and questionnaires were carried out.

The results of the study show no significant or distinctive difference in terms of perceived trust between groups. The results also don’t indicate any distinctive difference between the groups' situational awareness. There is marginal difference between the groups, with the group experiencing feminine voice having both higher perceived trust and situational awareness. The final result of this study shows that this research area needs to be explored further to discover and understand the possible effects of voice types in voice assistants.

Link to the final year student project in Swedish:
https://www.diva-portal.org/smash/record.jsf?pid=diva2%3A1773972

5. Conclusions, Lessons Learnt and Next Steps

Use case scenarios suggestions for the project:

1. Use-case scenarios for ADAS include lane departure warning, forward collision warning, adaptive cruise control, blind-spot detection, and automatic emergency braking.
2. Speed Management: Controlling vehicle speeds is crucial for preventing accidents. Use-case scenarios for speed management include speed limit enforcement, automated speed cameras, intelligent speed adaptation systems, and traffic calming measures.
3. Intersection Safety: Intersections are high-risk areas where vehicles converge. Use-case scenarios for intersection safety include traffic signal optimization, roundabout implementation, traffic enforcement at intersections, and intelligent intersection management systems.
4. Pedestrian Safety: Protecting pedestrians is essential in traffic safety. Use-case scenarios for pedestrian safety include crosswalk enhancements, pedestrian detection systems, signalized pedestrian crossings, pedestrian-friendly infrastructure design, and public awareness campaigns.
5. Cyclist Safety: Ensuring the safety of cyclists is another critical aspect of traffic safety. Use-case scenarios for cyclist safety include dedicated bike lanes, cyclist

detection systems at intersections, education programs for cyclists and motorists, and cyclist-friendly road infrastructure.

6. Vehicle Safety Standards: Ensuring that vehicles meet high safety standards is crucial. Use-case scenarios for vehicle safety standards include mandatory safety features such as seatbelts, airbags, stability control systems, crash tests, and safety rating systems.

Suggested major issues to address for improving ADAS in traffic safety:

1. System Integration and Fusion: ADAS systems often consist of multiple components and sensors that need to work together seamlessly. Ensuring proper integration and data fusion among these components is essential for accurate perception and decision-making. Harmonizing different sensor technologies and their outputs is crucial to create a cohesive and reliable system.
2. Human-Machine Interface (HMI): ADAS systems need to effectively communicate with the driver, providing clear and intuitive information about the system's status, warnings, and interventions. Designing an effective HMI that is easy to understand, minimizes distractions, and promotes appropriate driver behavior is essential for maximizing the benefits of ADAS while ensuring driver engagement and situational awareness.
3. Sensing Limitations: ADAS systems often utilize sensors such as cameras, radar, lidar, and ultrasonic sensors to gather information about the environment. However, these sensors can have limitations in certain conditions, such as poor weather, low visibility, or detecting certain types of objects (e.g., pedestrians or cyclists). Overcoming these sensing limitations is critical to provide consistent and reliable performance across various scenarios.
4. User Education and Acceptance: ADAS systems introduce new technologies and functionalities to drivers, requiring proper education and training to ensure their effective use. Drivers need to understand the capabilities and limitations of ADAS systems to use them appropriately and avoid over-reliance or complacency. Promoting user acceptance and addressing potential trust issues is crucial for the successful adoption and utilization of ADAS technologies.

The next step is to create larger projects where Scania will be included and HMI will be a focus area together with computational development of safety information.

7. Dissemination and Publications

These results are also a potential basis for a review article publication. This will be further considered given comments on this final report. The final year student publications will be further used as basis for the next experimental stages.

How are the project results planned to be used and disseminated?
Increase knowledge in the field:

- This increase in knowledge is the next phase of the interaction between drivers and driver support systems. This is the necessary next stage where computational modeling requires driver monitoring.

Be passed on to other advanced technological development projects:

- These results will be used to propose a larger project to work much longer to do experimental controls and applications.

Be passes on to product development projects:

- This is also a critical necessary factor given the necessary interaction between drivers and driver support systems.

8. Acknowledgement

The project has provided a valuable collaboration between the SAFER partners and the financial support from them. We have also a great appreciation for SAFER for the pre-study project and the financial support!

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