Ready, Get Set, Takeover. In the Course of Improving the Drivers' Situation Awareness.

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Abstract
With the proliferation of autonomous vehicles, the drivers are no longer engaged in the driving task and mostly called out-of-loop. For the currently offered levels of vehicle automation (i.e., SAE-L2) the users are required to be vigilant and to intervene when the system fails. In this position paper, we argue that the whole drive has to be considered when designing take over requests. Thus, the driver has to be continuously updated on the driving scene to be able to intervene appropriately if necessary. We also discuss different approaches of how to increase the driving scene awareness of the user.

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Autonomous Vehicles; Situation Awareness; In-vehicle Traffic Representation.

ACM Classification Keywords
H.5.2 [User Interfaces]: Information and presentation

Introduction
Automation is defined as technology that actively selects data, transforms information, makes decisions, or controls processes [6]. Advancements in vehicle automation allow drivers to take their eyes off the road and disengage from the driving task (e.g., Tesla's autopilot). That allows the driver to be involved in a non-driving related task (e.g.,

reading). Trusting that the car would perform the perceptional and decision-making tasks, the driver shifts his role to an out-of-loop operator rather than a fully in-control driver [1]. Current levels of automation (i.e., SAE-L2), however, expect the driver to be attentive to the road, supervise the car performance while driving and intervene in the failing instances [3, 11, 5]. When the system confronts a situation that matches a predefined situation, it acts accordingly (e.g., active braking system based on a predefined safety headway distance). Since it is unfeasible for the designers to take all the possibilities in different scenarios into account (i.e., failing instances), relying on human intervention is crucial. While automation facilitates the driving tasks, it therefore also leads to a major new challenge that is how to cognitively enable the driver to safely intervene when the system fails. Not only do the designers now need to implement an easy-to-use and understandable technology, but also they need to make sure that the operators are constantly vigilant and aware of the driving scene. To make sure that the drivers would be able to intervene on the right time, they have to be aware of the surrounding environment and at all time be able to assess the car actions given any situation. Therefore, designing, communicating, and representing the surrounding elements (e.g., surrounding traffic, street layouts) to a non-focused driver is critically important.

In this work, we present existing approaches that address this challenge, as well as, discuss different concepts that can support the driver in understanding the driving scene even implicitly.

Related Work

Most of the related work in the automotive UI domain has been focusing on Take Over Requests (TORs) design, yet, little work focused on including real-time driving scene representation for TORs. Supporting the driver to keep a comprehensive overview of the driving scene is a crucial task for UI and particular TOR designers.

Investigating TOR issuing time prior to critical events, Mok et al. [7] manipulated the issuing time (i.e., the time the driver has to take over control) and examined the drivers' performance in the presence of a non-driving related task (i.e., watching videos). They found that 2 seconds were not enough to get the drivers back into the loop. The 5 seconds on the other hand, if not necessarily the minimum, seemed to be enough for an inattentive driver to re-engage in the driving task and execute the proper action.

Other studies, such as Petermeijer et al. [8] focused on the modality used to communicate the TOR. They examined the interrelation between adapting different TOR modalities (e.g., auditory, visual, and tactile) to the various types of non-driving tasks (e.g., reading, talking on the phone, watching a video). Only a small effect was detected by adapting the TOR to the non-driving task (e.g., presenting a peep if the task is reading). Furthermore, the tactile and auditory TORs resulted in faster reaction times compared to the visual TORs.

To engage the drivers more in the driving scene, a lot of the leading car manufacturers integrated Head Up Displays (HUDs) in the newly offered highly automated vehicles (e.g., displaying the speedometer on the windshield) [10]. Some of the data projects on a HUD is function-oriented, like superimposing navigational data on the windshield in the BMW 5 series. Others, such as General Motors, tries to convey extensive data about the driving scene using several sensors and cameras such as night vision imaging systems. While this information helps in keeping the drivers more aware of the driving conditions and rules, they are not taking into consideration out-of-loop operators. Boström and Ramström investigated the use of graphical UI in a highly automated vehicle to keep a busy operator inside the driving loop [4]. They integrated a HUD with a windshield and showed that presenting the leisure functionalities (e.g., phone, SMS, music, weather, etc.) on the HUD, forced the drivers to pay more attention to the road. From a different perspective, Rezvani et al. examined the influence of different environment UI representations on the operators in the transitional phases where human control was needed [9]. They tested 3 transitional situations. The first is a takeover warning issued by the car without an immediate threat. The second is a sudden takeover request due to a detected static object (e.g., road barrier). The third is similar to the second but with a dynamic object (e.g., moving car). They presented the participants two designs. One with a general warning of the potential threat, without specifying which type (e.g., static or dynamic obstacle). The other one is with obstacle-related warning. The UI was presented on a HUD integrated with the windshield. Overall, the participants' performance was better in the case of the detailed UI representation compared to the general warning one. This reflects the importance of depicting a detailed-scene in improving the situational awareness.

An Holistic Approach to TORs

The previously mentioned studies focused on keeping the drivers in the loop and facilitating the transitional phases from automated driving to the driver being in control. However, they concentrated on the TOR event itself rather than taking the whole drive into consideration. We present ideas that take the whole drive into account and aim at giving the driver an understanding of the driving scene throughout the whole drive.

Implicit Integration of Scene in UI

One approach would be integrating the driving scene into the in-car UI. Thus, different UI elements are linked to the actual real world elements. For example, an earth defender game with "aliens" attacking the earth but they appear from the locations the cars in the real world are. When a car is driving right behind, these aliens are spawning at the bottom of the displays. To communicate the driving route, the animated objects could be flying in the direction of the route. So if a turn is ahead, the element would fly to the right or to the left mimicking the direction of the road.

Ambient Visualization of Scene

Another approach would be to use ambient feedback to highlight the driving scene similar to the work of van Veen et al. [12]. Ambient light has been shown to provide easy-noticeable and understandable feedback. While van Veen et al. propose using glasses, we believe that including the lights into the car interior. For example, having lights on the border of the ceiling of the car. During the drive, the ambient feedback could highlight the direction from which cars are approaching. If a car is approaching from the left, the left ceiling would light up. This might be achieved with a simple change in brightness.

Using Off-Screen Visualizations

Off-screen visualizations have mainly been used for maps to highlight points of interest not currently present on the viewport of the map. Examples of off-screen visualizations include halos or arrows [2]. For communicating the driving scene, we propose using these techniques to highlight the position of the surrounding traffic. Thus, each halo or arrow would depict a specific road user. The off-screen visualization could be shown on top of any interface to increase the drivers understanding of the traffic.

Conclusion

In this work, we highlight different means to improve the drivers' situation awareness in highly automated vehicles.

We thereby focus on the whole drive rather than the time during a take over request. We believe that considering the whole drive is crucial to make take over request safe. In the future, we will further explore how the different presented methods perform. By conducting driving simulator studies we will gain a further understanding of the role of the whole drive to support the take over request.

References

[1] J Elin Bahner, Anke-Dorothea Hüper, and Dietrich Manzey. 2008. Misuse of automated decision aids: Complacency, automation bias and the impact of training experience. *International Journal of Human-Computer Studies* 66, 9 (2008), 688–699.

[2] Patrick Baudisch and Ruth Rosenholtz. 2003. Halo: A Technique for Visualizing Off-screen Objects. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '03)*. ACM, New York, NY, USA, 481–488. DOI: http://dx.doi.org/10.1145/642611.642695

[3] Myra Blanco, Jon Atwood, Holland M. Vasquez, Tammy E. Trimble, Vikki L. Fitchett, Joshua Radlbeck, Gregory M. Fitch, Sheldon M. Russell, Charles A. Green, Brian Cullinane, and Justin F. Morgan. 2015. Human Factors Evaluation of Level 2 and Level 3 Automated Driving Concepts. *(Report No. DOT HS 812 182)* August (2015), 300. DOI: http://dx.doi.org/10.13140/RG.2.1.1874.7361

[4] Alexander Boström and Fredrik Ramström. 2014. Head-Up Display for Enhanced User Experience. 2014:015 (2014).

[5] Christian Gold, Daniel Damböck, Lutz Lorenz, and Klaus Bengler. 2013. "Take over!" How long does it take to get the driver back into the loop?. In *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, Vol. 57. SAGE Publications Sage CA: Los Angeles, CA, 1938–1942.

[6] John D Lee and Katrina A See. 2004. Trust in automation: Designing for appropriate reliance. *Human factors* 46, 1 (2004), 50–80.

[7] Brian Mok, Mishel Johns, Key Jung Lee, David Miller, David Sirkin, Page Ive, and Wendy Ju. 2015. Emergency, automation off: unstructured transition timing for distracted drivers of automated vehicles. In *Intelligent Transportation Systems (ITSC), 2015 IEEE 18th International Conference on*. IEEE, 2458–2464.

[8] Sebastiaan Petermeijer, Fabian Doubek, and Joost de Winter. 2017. Driver response times to auditory, visual, and tactile take-over requests: A simulator study with 101 participants. *Reading* 33 (2017), 24–3.

[9] Tara Rezvani, Katherine Driggs-Campbell, Dorsa Sadigh, S Shankar Sastry, Sanjit A Seshia, and Ruzena Bajcsy. 2016. Towards trustworthy automation: User interfaces that convey internal and external awareness. In *Intelligent Transportation Systems (ITSC), 2016 IEEE 19th International Conference on*. IEEE, 682–688.

[10] Michelle Krüger Silvéria. 2014. Virtual windshields: merging reality and digital content to improve the driving experience. *arXiv preprint arXiv:1405.0910* (2014).

[11] Society of Automotive Engineers. 2014. Automated driving levels of driving automation are defined in new SAE international standard J3016. (January 2014). [Online].

[12] Tom van Veen, Juffrizal Karjanto, and Jacques Terken. 2017. Situation Awareness in Automated Vehicles Through Proximal Peripheral Light Signals. In *Proceedings of the 9th International Conference on Automotive User Interfaces and Interactive Vehicular Applications (AutomotiveUI '17)*. ACM, New York, NY, USA, 287–292. DOI: http://dx.doi.org/10.1145/3122986.3122993