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 percep-
tional 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, ex-
pect 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 situa-
tion 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 ac-
count (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 imple-
ment an easy-to-use and understandable technology, but
also they need to make sure that the operators are con-
stantly 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 rep-resenting 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 rep-
resentation for TORs. Supporting the driver to keep a com-
prehensive 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
even 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 modali-
ties (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 sys-
tems. 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 easily 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


