AmbiCar: Ambient Light Patterns in the Car

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AutomotiveUI'15 September 1-3, 2015, Nottingham, UK
ACM 978-1-4503-3736-6

Abstract
In recent years, we looked into ambient light displays in the vehicle and possible applications. We investigated possible locations for the display and designed several designs for a light pattern which helps drivers when they want to change lanes. In the workshop we want to discuss our experiences so far, but also possible future applications for our light display. Furthermore, we are looking forward to see what other researchers define as ambient interaction and what they learned about it so far.

Author Keywords
light display; ambient interaction; human-centred design.

ACM Classification Keywords
H.5.m [Information interfaces and presentation (e.g., HCI)]: Miscellaneous

Using ambient light in the vehicle
We understand ambient displays as displays which are in the periphery of attention most of the time. In [4] we first proposed our idea of an ambient light display in the car as an alternative modality to displays that demand focused vision, vibro-tactile displays or sounds. Following the Multiple Resource Theory which is a model for the independent capacities of the individual senses [11], we argue that using an alternative modality may help, by not increasing

Figure 1: The preferred location for general information.

Figure 2: A complex light pattern that was proposed by a participant, but later rejected.

Figure 3: A simple pattern which the participants liked, but did not sketch in the design phase.

workload on the foveal vision. Further, ambient displays are able to switch from addressing foveal vision to addressing peripheral vision and back [10]. With various notification levels, as defined in [8], ambient displays are also able to get the drivers' attention at different levels of urgency. For example, while driving, a *change blind* notification may inform a driver about the current speed with a slow moving speedometer. A *make aware* notification might use abrupt changes, like switching the dashboard's color from green to red, in order to e.g. warn about speeding. The *interrupt* notification uses flashing, beeping, vibration, or something similar to get the user's attention and may be used as a more alerting warning, e.g. if getting too close to a car in front. At the level *demand action*, the interruption will not stop until the user reacted which is very distracting on purpose and should only be used in urgent cases.

Related to our work, other researchers have previously used ambient light displays in their works, e.g. the night vision enhancement system by Mahlke et al. [7]. A light display which helps drivers to decelerate earlier and more constant was developed by Laquai et al. [2] and a $360\,^{\circ}$ light display which directs a driver's attention to critical objects by displaying distance and position to them was created by Pfromm et al. [9].

In our studies, we were able to show that our ambient light patterns helped drivers in a driving simulator when changing lanes in a highway scenario: reaction times were reduced and gaps were safer [3]. In the process, it was difficult to visualize ambient light using paper or video. For example, in Figure 1, the room seems to be dark, just because the brightness of the picture is low to be able to see the color of the light display. Our solution was to get direct feedback of the participants as often as possible in order to avoid misinterpretations. For example, we designed different light patterns which should support drivers during lane change in a small workshop [5]. In a first session, participants sketched their designs which were analyzed and discussed afterwards. In a second session, we confronted the participants with prototypes for some of the designs and asked them for feedback. The second step was very important as it showed that there was sometimes a large gap between the participant's expectation and the actual behavior of the light. For example, Figure 2 shows the implementation of a complex design, where the ratio of red and green, as well as the movement of many light sources displays the gap size to a closing car. After seeing the implementation, the participant realized that this information is hard to decode, while it looked good on paper. However, we were able to derive other light patterns, such as the one in Figure 3, because of the direct feedback and lively discussions. These were not sketched by the participants, but matched their needs. Another problem arose when we were interested in light patterns for the *change blind* notification level: participants seemed not to know, which changes may

Figure 4: The final design for an overtaking scenario. If a car approaches on the left fast lane, a purple light moves towards the front left corner to display the distance. In addition its brightness adapts according to the assumed need for attention.

keep them informed without distracting them. However, they most often used a traffic lights metaphor to describe their desired light pattern. Hence, we first tested designs which followed the participants' proposals [6]. When this did not show significant effects, we redesigned the light pattern to fit to the driver's needs as described in [3] and shown in Figure 4. During this phase of our work, we learned how important it is to go beyond statements of participants.

Open questions

In our studies we saw significant effects on driving behavior. However, we were not able to see any effects on subjective data, such as workload which was measured using Raw TLX (RTLX), which is a NASA-TLX without weights [1]. In the workshop I would like to discuss how to measure user experience, workload, etc. without distracting the driver or switching his or her attention to the display. Furthermore, it would be interesting to discuss how to measure how "ambient" a display is. Are video observations or eye-trackers really the best way? They seem to be distracting and thus may distort the results.

Regarding the displays, we would like to see if a common understanding of ambient displays exists. We are interested in different types of ambient displays and the interactions that they give rise to, as well as relevant alternative scenarios as identified by other researchers. Finally, it will be interesting to discuss the impact of autonomous driving on ambient interaction. For example: Is it possible to keep a driver informed using ambient displays? How to design an interaction to get the driver's attention if he or she is not paying attention to the interface at all?

In general, we are looking forward to exchange ideas and best practices with other researchers from different domains in this workshop.

Acknowledgments

This work was supported by the funding initiative *Niedersächsisches Vorab* of the Volkswagen Foundation and the Ministry of Science and Culture of Lower Saxony as part of the *Interdisciplinary Research Center on Critical Systems Engineering for Socio-Technical Systems*.

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