Preventing monotony caused fatigue with Driver-Vehicle-Interaction – A design concept

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Abstract: Driving under fatigue is one of the main causes for deadly accidents in car and truck traffic. One of three reasons for fatigue, next to mental overload and sleep deprivation, is monotony. The article will detail a concept for an automotive driver-vehicle-interaction system that was developed to prevent monotony caused fatigue. Inspired through proven positive effects of a co-driver in monotone driving situations, the driver-vehicle-interaction system will be a technical realization of a passenger. A passenger has both positive and negative influences on the driver. The goal for the driver-vehicle-interaction system is therefore to replicate the positive influences while avoiding the negative. The system will - like a passenger - animate the driver to talk, think and listen. In order to avoid distraction all interaction will be based on the driving situation itself. Therefore, the driver is not distracted by a secondary task, but the actual monotonous driving task is interesting again by new stimulus. For example, the driver is asked by the driver-vehicle-interaction-system to maneuver the vehicle center as precisely as possible in the middle of the lane for one minute. This task addresses an increasing difficulty for the drivers to keep the lane in monotone driving situations. In addition, 13 tasks and questions where developed to maintain the driver's vigilance. In order to motivate the driver to use the system, the interaction is gamified. The gamification implies a feedback for the driver on his fulfilment of tasks combined with a rewarding scoring system against other traffic participants. At this state the concept is developed to be tested in a simulated driving scenario.

Keywords: Driving, Simulator, Fatigue, Monotony, Interaction

1. Introduction

Sleep related road accidents are a permanent danger for drivers and their environment. A study by Horne & Reyner, 2001, performed in U.K., shows that sleep related accidents make up to approx. 15-20% of all accidents in which the police is called. Other researchers (e.g. Langwieder, Sporner, & Hell, 1994). validate the number even though drowsiness as a cause is more difficult to prove than other causes as drugs and alcohol. However, drowsiness causes more accidents then the consumption of drugs and alcohol (Akerstedt & Wright, 2009). Therefore, a need to decrease the probability of a sleep related accident is a priority topic not only in the automotive industry but also in research. Since driving Fatigue is among mental overload and sleep deprivation promoted by a mental underload, it is striven for to fight the latter by this research.

To cope with monotony while driving, the driving process itself is targeted. With the basic idea of implementing gamification elements into the driving task the monotony is supposed to vanish and the interest of the driver into the driving task is supposed to maintain. In recent years, the term gamification gained popularity in academics as well as in various fields of industry. While gamification is defined as “use of game design elements in a non-game context” (Deterding, 2011), it is widely used to encourage a desired behavior.

A concept of a driving assistant system based on a click dummy was developed as a prototype (Bier and Bruder 2017).

2. Methodology

2.1 Prototype Software Axure

The software used to build up the prototype is called Axure. Axure can be used for rapid prototype of websites and apps. It is not only suitable for concept and design purposes but also for rapid prototyping. The dynamic panel provides the user with a wide range of options for static and dynamic interaction design possibilities which can be linked via logic relations and event happenings.

The content of Head Up Display (HUD) and the screen in the middle console of the car (LCD) are visible for the Wizard in the upper area. The content of the HUD is shown on the left. Its size is fix and accords with the proportions of the smartphone which projects the HUD onto the windshield of the car. On the right side the LCD is shown and it is also adapted to the proportions of the tablet, which represents the middle console screen in the experiments.

In the bottom screen area, the interface for the wizard is placed. This area is visible for the experimenter only. By this interface, it is possible to show the experimenter the content of the HUD and LCD. This ensures the controllability, which was mentioned in the requirements for the experimenter.

In general, the driver can give input by his voice. If the driver interacts with the system, the wizard must trigger the corresponding action, by clicking a button in the experimenter area as illustrated in figure 1.

Figure 1. *Segmentation of the axure screen into different interaction areas (left) – Interaction example for the game “name the last traffic sign passed” (right)*

2.2 Wizard of Oz Concept

The driving test for evaluation will be carried out in the institutes driving simulator (static, almost 360 degree view, real car mockup) as it is to be expected that monotony is independent of the environment and can be simulated more robustly in a simulator than on a test track or in actual real life traffic. The simulator runs with the SILAB 5.1 software, developed by WIVW.

The software prototype of the assistant system is developed as a *Wizard of Oz*, to simulate the interaction between a driver and a driver assistant interface.

Wizard of Oz Experiments are used to simulate the interaction between a person and a computer interface. In this type of experiment there is a test person who interacts with a system that cannot work autonomously. Spaced apart from the test person another person, the “wizard”, controls the whole system (see figure 2). That means, that the interacting person only assumes to be directly connected to the system. In fact, the whole communication between the person and the computer interface is controlled by the “wizard”. So, the test person behaves like in a real experiment, even if the whole interaction is based on the activity of the “wizard” (Dahlbäck, Jönsson, & Ahrenberg, 1993; Hajdinjak & Mihelic, 2003).

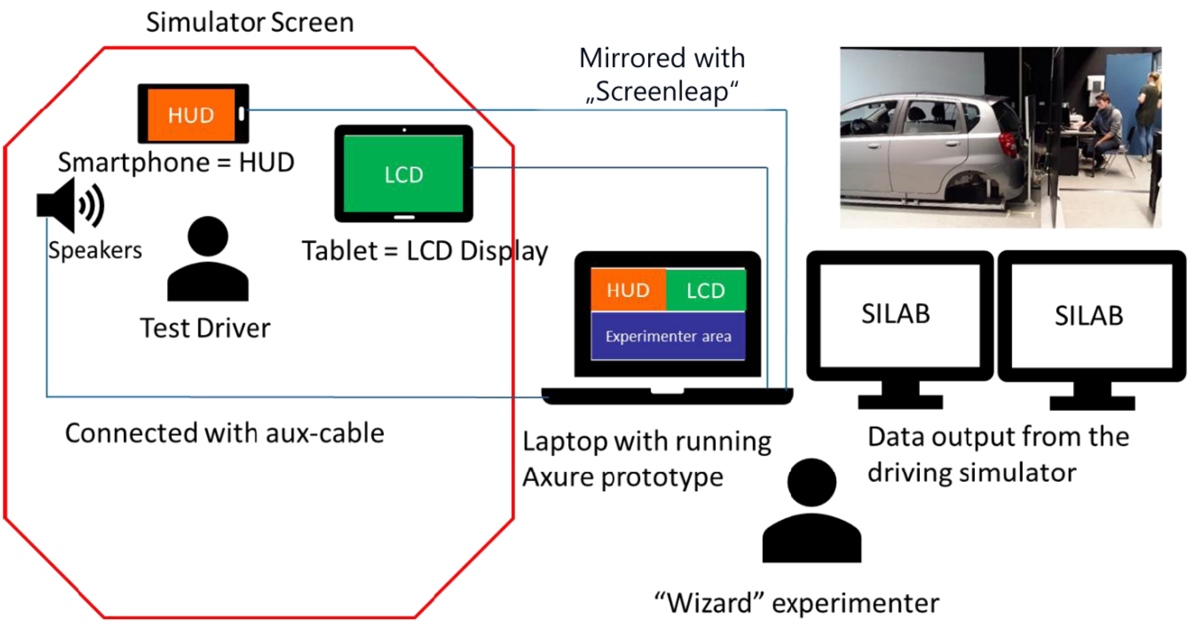

Figure 2. *Concept to implement the prototype into the driving simulator*

3. Developed Assistant System and Discussion

The main features of the concept are gamified tasks for the driver, which are added to the driving task. In the presented work, these tasks are three driving games and a quiz. The virtual co-driver suggests the driver to play a game or a quiz to break the monotony of the driving task. The communication between driver and assistant system is designed as a conversation between real people. The games and the quiz

are to be designed in such a way, that they do not put cognitive load on the driver to an extent where the driving activity is affected by using vocal interaction solely and giving intuitive visual feedback only related to the driving task.
The concepts of the three games are listed below:

1. Maintain the position in the middle of the driving lane for 60 seconds
2. Maintain the speed for 60 seconds
3. Maintain the distance to the vehicle ahead for 60 seconds

The games engage the driver directly into driving better and by having more game options, the driver gets new stimuli whenever he feels bored by driving. Hence, common driving errors (Horne und Reyner 2001) are incorporated as games into the design of the prototype, namely drifting away from the lane, erratic speed and acceleration, getting too close or too far away from the vehicle ahead.
In addition to those games, that directly affect the drivers behavior and his motor skills in a counteract to the monotony effects, we implemented eleven quiz questions to keep the drivers cognition upright.

3.1 Questions recarding traffic signage and applicable speed limits

The two tasks "name the current maximum speed" and "name the last traffic sign passed" target a maintenance of track observation by the driver, even in monotonous driving situations. In addition, the questions require the driver to activate his cognition and thus contribute to a possible activation of the driver as a whole and may increase his situational awareness.

3.2 Questions about covered distance and elapsed time since the start of the journey

The two questions "estimate your current journey time" and "estimate your distance covered so far" pursue the goal of making the driver aware of the route he has traveled so far and thus the progress made in accomplishing the task. In this case, a cognitive activation is to be achieved by a distance estimation of the driver, in addition, the already mentioned representation of the achieved progress can lead to an increase in motivation of the driver.

3.3 Questions about distance and elapsed time since certain objects

In this category we ask questions which referred to a specific track feature like a bridge crossing or traffic sign. The river has to estimate what time has elapsed since this event or which distance he has traveled. These questions links up those estimation tasks, presented in the previous section, with the general task of track observation.

As shown in the previous section, an estimation task generates cognitive load, which can activate the driver in a monotonous driving situation. In addition, here the element of the route observation is used, which is an important aspect for the safe performance of the driving task. It is to assume that no additional visual burden is laid on the driver as the watchful observation of the route is an elementary part of the actual driving task anyway.

3.4 Questions related to other road users

Questions relating to other road users on the one hand serve the active traffic observation by the driver, but they also support him in terms of keeping the safety distance to other vehicles. In this case, the activating component of this type of questioning consists of the estimation process of the distances as well as estimation of the relative speeds the secondary and the own vehicle. The questions presented here serve the purpose of supporting active traffic monitoring by the driver. The observance of correct distances is a safety-relevant part of the driving task. According to Greschner (2011), the ability to estimate distances decreases under the influence of fatigue and is therefore actively supported by these types of questions. In addition, the re-existing estimation component provides driver cognitive activation.

It is furthermore strictly necessary for the aspect of gamification, that the driver gets a feedback about his game-performance. The developed prototype gives the wizard the opportunity to rate the game performance of the driver basing on the collected data about the driving behavior. In this way the wizard gives a direct feedback to the driver through the interaction system that may motivate the driver on the remaining journey.

However, for long, monotonous driving situations the driver may get bored by playing the game for the whole drive. Furthermore, the task to drive smoothly may not be well defined for gamification purpose. Moreover, the game would not stimulate the driver with new impulses. Therefore, the gamification is occurring in intervals. Every ten minutes an interaction will start, containing one out of three driving tasks and three out of eleven quiz questions. The driver will soon realize that the questions recur and will therefore be motivated to pay more attention to the driving task in order to achieve higher in the games.

4. Conclusion

By means of gamification, the developed Interaction System is developed to integrate the driver into the driving task in a monotonous driving situation. This will counteract monotony, improve driving performance and therefore increased road safety.

By using state of the art sensor technology, such as distance sensors, lane detection systems and sensors to detect the fatigue of the driver, the concept can already be technically implemented today. It will both actively respond to the condition of the driver and to the vehicle environment.

The distraction of the driver from the actual driving task is largely avoided by minimizing the visual stress. In the design of the games, care is taken to avoid a negative emotional charge of the driver through suitable formulations and symbols in order to increase his motivation. The designed driving games specifically pick up performance measures of the driving task and use the natural play instinct of the driver to improve the driving performance. A reward system for good driving performance will maintain the driver's motivation to use the system.

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