Tutorial on Design and Evaluation Methods for Attention Directing Cues

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ABSTRACT
Managing drivers' distraction and directing their attention has been a challenge for automotive UI researchers both in industry and academia. The objective of this half-day tutorial is to provide an overview of methodologies for design, development, and evaluation of in-vehicle attention-directing user interfaces. The tutorial will introduce specifics and challenges of shifting drivers' attention and managing distractions in semi- and highly automated driving context. The participants will be familiarized with methods for requirement elicitation, participatory design, setting up experiments, and evaluation of interaction concepts using tools such as eye-tracker and EEG/ERP.

ACM Classification Keywords
H.5.m. Information Interfaces and Presentation (e.g. HCI): Miscellaneous

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in-vehicle displays; driver distraction; automotive user interfaces; evaluation methods; attention-directing cues; eye-gaze analysis; EEG/ERP measurements;

INTRODUCTION
Increasing vehicle automation radically transforms the role of the driver from one of vehicle handling to that of vehicle supervision. On the one hand, it has the potential of allowing the driver to manage more tasks, in addition to vehicle handling, than was previously possible. On the other hand, it relegates the prominence of vehicle handling and introduces steering-irrelevant tasks that will compete for the driver's limited cognitive resources. These tasks which vary from route navigation to working with infotainment devices such as mobile phone or tablet PCs, provide users with a considerable amount of information. Thus, a futuristic in-vehicle environment that relies heavily on control of automation, raises a vital question: How can we support a driver's ability to seamlessly switch from engaging with a non-vehicle-handling task to monitor and/or resume the diverse complex maneuvers that constitute effective vehicle handling?

Against this context, user interface designers and researchers are challenged to design and develop user interfaces that will support the seamless shifting of attention between different in-vehicle task domains. To achieve this, it is necessary to include test participants in the design and evaluation process of developing in-vehicle human machine interfaces (HMI). This involves running experiments and tests on prototypes of the HMIs and evaluate them in lab, simulations, or real-world scenarios.

In this tutorial, we will provide an overview of the user centered design approach for attention directing cues, quick prototyping, and evaluation methods such as usability testing. In addition, we will explain the use of eye-tracking and EEG/ERP techniques in inferring drivers' attention and information processing.

BENEFIT/OUTCOME
During this tutorial, participants will be introduced to challenges in designing displays to direct drivers' attention in semi and highly automated driving scenarios. They will learn how to elicit requirements for designing such interfaces and how to involve users in different design phases. They will be given an introductions to low- and medium-fidelity rapid prototyping methods to translate interaction concepts and designs into working prototypes which can be evaluated y users. Participants will learn about how to set up an experiment to evaluate their concept depending on their research questions and/or

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system prototype. In addition they will learn about evaluation methods for assessing usability of the system and drivers' performance by using tools and equipment such as questionnaires, driving simulators, eye-tracker, and EEG/ERP.

CONTENT

This half-day tutorial will consist of three parts. We will begin by briefly introducing the challenges involved in manipulating drivers' attention in an in-vehicle scenario. This part will take into account examples from current and future driving scenarios, wherein design, modality, and saliency of in-vehicle displays can be expected to play an important role in drivers' safety.

In the second part, we will introduce the iterative process of designing, prototyping, and evaluation of attention directing displays, particularly in the context of an automotive environment. Along the user-centered design approach, we will present examples from our previous experiments for designing attention cues. As a first step, we will explain how we elicit requirements with the combined use of brain-storming, elicitation studies, interviews, informal observations and questionnaires, interaction concept development (e.g., design workshops) and quick-and-dirty prototyping, and low-fi prototyping. Following this, we will discuss the use of different experiment setups from low-fidelity laboratory studies to fixed-base driving simulators to real-world testing. Finally, we will initiate and facilitate a discussion of the "do"s and "don't"s of different experiment set-ups and study designs for evaluating developed prototypes. In particular, we will cover topics such as pilot testing, prototype saliency and ergonomics testing. We close this part by introducing established evaluation methods, from usability testing to final evaluation. This will consist of qualitative methods such as observations, questionnaires, think aloud technique, Wizard of Oz, interviews, as well as quantitative methods in the context of driving performance evaluation such as assessing measures like reaction times, time-to-collision, lateral deviation, and others.

In the third part of the tutorial, we will focus on how non-obtrusive measurements could be used to evaluate the effectiveness of attention directing cues. In particular, we will focus on how gaze-tracking and EEG/ERP measurements can be relied on to make inferences with regards to information seeking and processing in an automotive context. Attention has two distinct bottlenecks. At the sensory level, visual information is better resolved in the central foveal region (2○) relative to the rest of the visual field. Thus, eye-movements occur at a rate of approximately 4 times per sec in order to fixate task-relevant information in the visual scene, be it for the purposes of lane-changing or for scanning one's Twitter stream. At the cognitive level, some information can be preferentially processed over others. EEG/ERP measurements can indicate preferential information processing. This section will provide a primer on how eye-tracking and EEG/ERP have been employed in basic research to understand attentional processes and how they can be applied in the context of automotive scenarios. We will explain how eye-tracking and EEG/ERP functions and the practical considerations of data-collection. In addition, we will present sample datasets from experiments and walk participants through the data-processing steps of these measurements. We will end this part of the tutorial with a discussion of how gaze-tracking and EEG/ERP measurements could be effectively employed in the user-case scenarios of the participants.

Target Audience and Prerequisites

This tutorial addresses a broad audience, from graduate students to experienced researchers, across the fields of HCI and Automotive UI research in industry as well as academia. The content of tutorial will interest individuals willing to learn quick prototyping methods and the non-obtrusive methods to evaluate their prototypes. The expected audience should have a basic knowledge of HCI gained from either attendance at a university course, or project work experience.

Presentation Format/ Tutorial Style

This tutorial will be presented in a mixed format that will include short 15 minutes lectures with interleaved hands-on sessions for each theme, with a Q&A and discussion session between each theme. The goal is to allow participants to interact with the instructors and to raise challenges to the presented techniques, from their own research context. After attending this workshop, participants will know which EEG methods are useful for evaluating their prototypes and what considerations have to be taken when designing an experiment. They will also have gained experience in data-processing using sample datasets and will have learned a first approach to guide them through future analysis.

Instructor Background

Shadan Sadeghian Borojeni is a researcher at the Interactive Systems group at OFFIS – Institute for Information Technology in Oldenburg, Germany. Her research investigate ways to support task switching and take over situations in highly automated driving using multi-modal cues evaluated in driving simulator experiments[7, 8].

Lewis Chuang leads research on "Cognition and Control for Man-Machine Systems" at the Max Planck Institute for Biological Cybernetics (Tuebingen). His research investigates information-seeking and -processing behaviour, especially in the context of man-machine systems, by relying on gaze-tracking and EEG/ERP methods [1, 2]

Andreas Löcken is a researcher in the Media Informatics and Multimedia Systems Group at University of Oldenburg in Germany. Currently, he is searching for a way to unobtrusively display information to drivers to enhance safety and comfort without disrupting them from their main driving task. Hence, he is interested in automotive user interfaces, ambient displays and HCI in general. He develops his concepts and prototypes following user-centered design. Therefore, he conducts various user studies, including for example interviews, usability tests or experiments in a driving simulator [5, 6].

Christiane Glatz is a researcher at the Cognition and Control for Man-Machine Systems group at the Max Planck Institute for Biological Cybernetics (Tuebingen, Germany). Her research investigates how auditory warning signals can cue and

sustain visual attention during steering and how these alerts are processed in the brain, using EEG [3, 4]

Susanne Boll is full professor for Media Informatics and Multimedia Systems at the University of Oldenburg and a member of the board of the OFFIS-Institute for Information Technology. Her research interests lie in the field of humanâĂŞcomputer interaction (HCI), specifically in the area of pervasive user interfaces, mobile, and wearable interactive systems. Her scientific results have been published in competitive peer-reviewed international conferences such as CHI, MobileHCI, AutomotiveUI, DIS, ACM Multimedia and IDC, as well as internationally recognized journals.

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