Editorial

Andreas Riener* and Alexander G. Mirnig

Guest Editors Introduction to the Special Issue "User-Centered Design for Automated Vehicles: HMIs, User Needs, and Preferences"

https://doi.org/10.1515/icom-2019-0014

1 Motivation/Rationale for This Special Issue

Automotive user interfaces pose numerous challenges to support a diverse range of user needs [1]. This is especially true when it comes to technology for vehicle automation, which is connected to – often widely – different expectations, depending on experience, demographics, amongst others. Automated vehicles are eventually expected to be used by both experienced and inexperienced drivers, drivers with high versus low technology affinity, or by thrill-seeking, young novice drivers as well as elderly drivers [2] with a mostly opposite set of preferences together with their natural limitations [3]. From a user-centered perspective, it is a spectrum composed of opposites, which translates into a number of design challenges that will need to be addressed eventually.

Implementation-wise, the automotive industry is currently focusing on pushing in-vehicle technology towards fully automated driving, with tech companies joining these efforts to raise the technology to the readiness level as quickly as possible. Consequently, commercial research toward automated driving systems (ADS) is mainly focusing on an innovation-driven and technology-centered perspective, frequently focusing on novelty-related factors. Aspects such as user experience (UX), acceptance, and trust [4, 5] are often neglected or reduced to a secondary status and, thus, under-researched. However, these human factors are critical for a comprehensive and long-term establishment of ADS technology on both the market and within society. Therefore, it is of utmost importance to understand all the factors in the (context of automation) that have an impact on the overall UX of and within an automated vehicle [6]. This includes operators of automated vehicles, vehicle passengers, and any other traffic participants affected by automated vehicles. We believe that there is a need to focus on a human-centered design (HCD) perspective to raise ADS innovation to the next level and, thus, to achieve wide acceptance in society that is justified by an appropriately sophisticated technology.

This special issue aims at filling this gap by presenting work that fosters the assessment of user-centered qualities of automated in-vehicle interaction technology. Furthermore, this special issue is intended to discuss special requirements of user-centered design applied to automated driving to solve essential challenges and identify opportunities for further research and development.

***Corresponding author: Andreas Riener,** Technische Hochschule Ingolstadt, Ingolstadt, Germany, e-mail: andreas.riener@thi.de
Alexander G. Mirnig, Salzburg University, Salzburg, Austria, e-mail: alexander.mirnig@sbg.ac.at, URL: http://hci.sbg.ac.at/mirniga

2 Submissions and Review Process

The articles submitted to this special issue have undergone a rigorous peer-review process and at least two independent reviewers reviewed all manuscripts. In addition, the guest editors performed meta-reviews on the articles in each round of review (up to three), and finally – according to an objective score sheet – four submissions were selected for publication.

3 Summary of Contributions

All articles accepted for the special issue on "User-centered Design for Automated Vehicles: HMIs, User Needs, and Preferences" address topics related to user-centered aspects in automated driving from different angles. The first article explores VR in-vehicle-entertainment systems and their effect on entertainment experience while the vehicle is in motion. The second article investigates augmented reality (AR) windshield displays for automation levels 3 and 5 with a focus on content type and placement on the windshield. The next article in this issue looks at the needs and requirements of passengers of

autonomous buses in enhancing their situation awareness and to communicate intent on a visual screen inside the bus. Finally, in the last article, the authors investigate user preferences in HMI design (modality and procedure) for take-over requests (TORs) and argue for personalized TOR displays.

In more details, the contributions (ordered by date of acceptance) are as follows: In the first article "*Challenges and Requirements of immersive media in autonomous car: Exploring the feasibility of virtual entertainment applications*", Wienrich and Schindler compare different in-vehicle entertainment systems and formats (2D vs. 3D and tablet vs. Head-Mounted Display (HMD) regarding their effects on user experience, presence, comfort or discomfort, and simulator sickness. Their results suggest VR-based entertainment (via an HMD device) to be suitable for in-vehicle content consumption over extended periods of time, with higher UX scores and only a limited increase of simulator sickness scores over the tablet condition. While their results are limited to vehicles with smooth movements only and content with an average maximum duration of 25 minutes, they do point towards a promising direction for further in-vehicle entertainment development.

In the second article "*Augmented Reality Windshield Displays and their Potential to Enhance User Experience in Automated Driving*", Riegler et al. present the results from a simulation-based user study, in which they collected user preferences regarding information content types, their position and other factors related to AR-based visualization on the windshield. Their results provide a comprehensive basis for both conditional (Level 3) and fully automated (Level 5) driving modes depending for the five content types *warning*, *vehicle-related*, *work-related*, *entertainment*, *and social media*. Values for perceived importance, preferred transparency, as well as differences regarding age, gender, and driving environment are provided as well. Thus, the article constitutes a solid and comprehensive basis AR-based visualizations in the vehicles of the near and far future.

In "*What's the Robo-Driver up to? Requirements for Screen-based Awareness and Intent Communication in Autonomous Buses*", Peter Fröhlich, Raimund Schatz, Markus Buchta, Johann Schrammel, Stefan Suette, and Manfred Tscheligi investigated future passengers' needs and requirements for screen-based awareness and intent communication in autonomous (shuttle) buses. The authors ran two user studies and collected data regarding needs for awareness and intent communication.

Results are three-fold and suggest, firstly, that passengers of autonomous buses might want to get information to give them a better awareness of behavior and intent of the bus. In addition, the authors found that awareness and intent communication may be of greater importance for the indication of potential hazards as compareed to showing regular route directions. Finally, participants had no clear preference over the three compared types of visual communication (text, icon, augmented reality), however, results suggest that a combination might be the best option due to the diversity of users/passengers and the complementary style of the three types. The article provides interesting insights and design recommendations for public transport operators interested in bringing autonomous buses in operation.

In the fourth article "*Drivers' Individual Design Preferences of Takeover Requests in Highly Automated Driving*", Sandra Epple and Stefan Brandenburg aimed at investigating individual user preferences regarding the human-machine interface design of take-over requests (TORs). In an online questionnaire with n = 53 subjects, potential drivers of highly automated cars were requested to evaluate eight different TORs (variation of visual and/or auditory TOR modality as well as TOR procedure). The interfaces were communicated in form of short video clips. Results showed that participants preferred a two-step procedure using text and speech to communicate TORs. In addition, results indicate that there is a significant difference in the perceived user experience and the subjective rating of emotions between the different TOR interfaces. The authors conclude that individual preferences regarding the design of TOR interfaces should be considered for future vehicles and is, thus, valuable for any researcher/designer working in the area of automated driving.

4 Conclusion

Technology for automated vehicles continues to progress and, with increasing level of automation, the user is more and more being forced into a passive role. Not only is this expected to increase on-road safety overall, it will furthermore enable the (former) driver to use the time in the vehicle more effectively by engaging in non-driving related tasks (NDRTs). Nevertheless, for a long period of time of transition from manual to fully automated vehicle technology, the user will need to be able to monitor vehicle/traffic behavior and be ready to take over control, potentially on short notice. Technological progress (sophisticated assistance systems, non-deterministic machine learning algorithms, amongst others) and effects caused by detachment from the driving task (de-skilling, lack of situational awareness) will require new ways and means to "keep the

driver in the loop – when required" and guarantee road safety in (conditional) automation. In HCI, (the design and representation of) the user interface is considered the most critical issue for effective and efficient interaction. While academia and industry do both aim towards reaching full on-road automation eventually, the transition phase, even if expected to be only temporary, can and should not be ignored if technological progress is to serve its primary purpose in addressing the needs of its human users. In this special issue, the authors of the four accepted articles have contributed to this problem field with solutions related to the fulfilment of user needs and (individual) preferences, system transparency (explainable UIs) to improve on trust/acceptance, and user experience in general.

To conclude this editorial, we thank the authors for their high-quality contributions to this issue and the automotive research and design communities as a whole. We greatly appreciate all the hard work that authors, reviewers, and the publishing office contributed to shaping this special issue. We now cordially invite you to a journey through a collection of high-quality research articles compiled in this special issue on "User-centered Design for Automated Vehicles: HMIs, User Needs, and Preferences".

Guest Editors
Andreas Riener
Alexander G. Mirnig

References

[1] Bastian Pfleging, Maurice Rang, and Nora Broy. 2016. Investigating user needs for non-driving-related activities during automated driving. In Proceedings of the 15th International Conference on Mobile and Ubiquitous Multimedia (MUM '16). ACM, New York, NY, USA, 91–99. DOI: https://doi.org/10.1145/3012709.3012735.

[2] Anna-Katharina Frison, Laura Aigner, Philipp Wintersberger, and Andreas Riener. 2018. Who is Generation A? Investigating the Experience of Automated Driving for Different Age Groups. In Proceedings of the 10th International Conference on Automotive User Interfaces and Interactive Vehicular Applications (AutomotiveUI '18). ACM, New York, NY, USA, 94–104. DOI: https://doi.org/10.1145/3239060.3239087.

[3] Andreas Riegler, Philipp Wintersberger, Andreas Riener, and Clemens Holzmann. 2018. Investigating User Preferences for Windshield Displays in Automated Vehicles. In Proceedings of the 7th ACM International Symposium on Pervasive Displays (PerDis '18), Albrecht Schmidt, Julie R. Williamson, Ivan Elhart, Matthias Baldauf, Mateusz Mikusz, Salvatore Sorce, Katja Kurdyukova, Passant El.Agroudy, and Vito Gentile (Eds.). ACM, New York, NY, USA, Article 8, 7 pages. DOI: https://doi.org/10.1145/3205873.3205885.

[4] Philipp Wintersberger, Anna-Katharina Frison, Andreas Riener, and Tamara von Sawitzky. 2019. Fostering User Acceptance and Trust in Fully Automated Vehicles: Evaluating the Potential of Augmented Reality. In Presence, vol. 27, no. 1, pp. 46–62, March 2019. DOI: 10.1162/pres_a_00320.

[5] Alexander G. Mirnig, Sandra Trösterer, Alexander Meschtscherjakov, Magdalena Gärtner, and Manfred Tschelig. 2018. Trust in Automated Vehicles. In i-com, vol. 17, no. 1, pp. 79–90. https://dblp.org/rec/html/journals/icom/MirnigTMGT18.

[6] Anna-Katharina Frison, Philipp Wintersberger, Andreas Riener, Clemens Schartmüller, Linda Ng Boyle, Erika Miller, and Klemens Weigl. 2019. In UX We Trust: Investigation of Aesthetics and Usability of Driver-Vehicle Interfaces and Their Impact on the Perception of Automated Driving. In Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems (CHI '19). ACM, New York, NY, USA, Paper 144, 13 pages. DOI: https://doi.org/10.1145/3290605.3300374.

Bionotes

Andreas Riener
Technische Hochschule Ingolstadt, Ingolstadt, Germany
andreas.riener@thi.de

Andreas Riener is a professor for Human-Machine Interaction and Virtual Reality at Technische Hochschule Ingolstadt (THI), Germany with co-appointment at CARISSMA (Center of Automotive Research on Integrated Safety Systems and Measurement Area). He is further leading the human-computer interaction group (HCIG) at THI. His research interests include driving ergonomics, driver state estimation from physiological measures, human factors in driver-vehicle interfaces as well as topics related to (over)trust, acceptance, sytem transparency/explainable UIs, and ethical issues in automated driving.

Alexander G. Mirnig
Salzburg University, Salzburg, Austria
alexander.mirnig@sbg.ac.at
http://hci.sbg.ac.at/mirniga

Alexander Mirnig is a research fellow at the Center for Human-Computer Interaction, University of Salzburg. His areas of expertise are in Human-Computer Interaction in Semi-automated Vehicles, Passenger Interaction in Automated Public Transport, Vulnerable Road Users in Automated Traffic, Ethical Issues in Automation Technology, Design Patterns, Philosophy of Science for HCI.