Introducing Automated Driving to the Generation 50+

Jingyi Li
LMU Munich
Munich, Germany
jingyi.li@ifi.lmu.de

Andreas Butz
LMU Munich
Munich, Germany
butz@ifi.lmu.de

Kai Holländer
LMU Munich
Munich, Germany
kai.hollaender@ifi.lmu.de

AutomotiveUI '19 Adjunct , September 21–25, 2019, Utrecht, Netherlands

ACM ISBN 978-1-4503-6920-6/19/09.
https://doi.org/10.1145/3349263.3351329

Abstract

Automated driving could promote safety and comfort in everyday traffic by reducing the human factor in vehicle control and traffic flow. Especially older people can benefit from such a technology, since age may have an impact on the driving ability. However, only few driving assistance systems focusing on the needs of the generation 50+ also consider opportunities of highly automated vehicles, such as the usage of head-mounted displays while driving. In a survey with drivers of 50+ years (N=26), we found that 81% had a basic knowledge of automated vehicles (AVs) but 73% would not buy an AV or are in doubt. In this WIP report, we present our research approach leading to a novel system for automated driving, addressing the needs of the generation 50+. We believe that the proposed system can foster the safety and acceptance of users in this age group and beyond.

Author Keywords

Automated Driving; Generation 50+; User Experience; Acceptance; User-Centered Design

CCS Concepts

•Human-centered computing → User centered design; Participatory design;

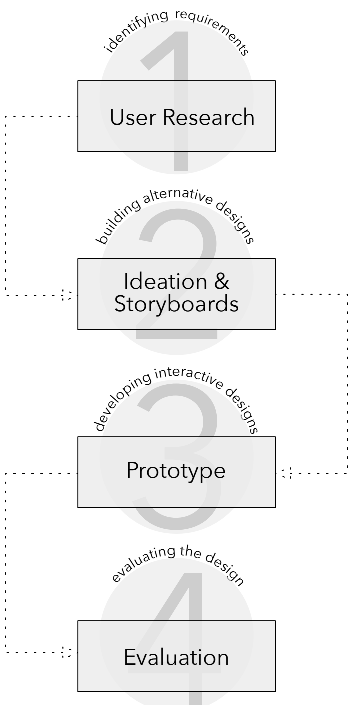

Figure 1: The phases of our design process.

Introduction

Automated driving is expected to reduce road accidents by decreasing human influence on vehicle control and traffic flow. It could increase safety and comfort while driving. However, in order to create an acceptance of automated vehicles it is crucial to present convincing products to the early adopters. MIT AgeLab director Joseph Coughlin predicts that consumers over 50 years will be the first to purchase smart cars[1]. Hence, people of this age group might become these early adopters of self-driving vehicles. Another main reason could be their financial capacity. However, only few researchers have tried to identify the needs of the generation 50+ and to develop corresponding solutions. Our aim was to learn about attitudes, problems and expectations in manual and automated driving. We therefore asked 26 drivers of 50+ years about their usual purpose of driving, challenges and unsatisfying experiences while driving. Furthermore, about their willingness to buy an AV, concerns about AVs and expected benefits. We then conducted a focus group with six HCI experts and developed concepts for novel driver assistance systems based on the survey results. We created three storyboards for promising concepts and selected one idea to build a VR prototype. We invited another five participants to evaluate the prototype. At this point we cannot yet report on the validation, as this is still work in progress. Instead, we report our research and design process and survey results.

Related Work

In 2017, 962 million people worldwide were older than 60 years. This number is expected to double by 2050[2]. At the same time, senior drivers consider their quality of life highly connected to individual mobility [16]. This means that aging drivers will be an increasingly critical factor of road safety. They are affected by age-related changes in sensory, motor and cognitive functions [23]. Vision provides 85-95% of the sensory cues in driving [13] and cognitive abilities such as selective attention [15] and spatial cognition [21] also decline with age. Aging drivers therefore often adjust their driving strategies to avoid dangerous situations, such as night driving, poor weather and rush hours [4]. In a study on the acceptance of automated driving systems (ADS) [6], the meaning of comfort and experience differed between the younger (entertainment) and the elderly (driving assistance) age group. Similarly, Abraham et al. [1] found that older adults generally were willing to use some level of automation, but were less interested in fully automated driving than the younger generation. There are mixed results on how much the demonstration of a new technology to its target users increases their willingness to buy it [6, 14]. Boot et al. [3] claim that experience with new technologies may at least increase the willingness to use them. We therefore consider it critical to clearly describe the benefits of advanced driving assistance systems (ADAS) to the target user group. Additionally, Furlan et al. [7] state that technology which is designed with the needs of aging drivers in mind is likely to benefit other age groups as well. Likewise, Frison et al. [6] argue that researchers and practitioners should support universal design and fulfill individual needs for any users of ADAS. People from the generation 50+ have a high potential of being the first adopters of automated driving technology, due to their financial capability. Consequently, we focus on users of this age group and develop concepts based on their needs. However, our concepts might benefit drivers of all ages.

Research and Design Process

Our research and design process includes one iteration through three of four main design phases, as shown in Figure 1. It is adopted from the basic activities of interaction design: (1) identifying requirements, (2) building alternative designs, (3)

[1] Bloomberg Interview, *accessed: June 2019*
[2] World Population Ageing, *accessed: June 2019*

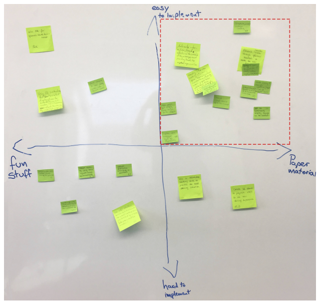

Figure 2: Sorting of created ideas during focus group. The labels for the x-axis are *fun stuff* (left) and *paper material* (right). The y-axis ranges from *hard to implement* (bottom) to *easy to implement* (top). The ideas were discussed and placed according to the axes within the focus group.

developing interactive designs, and (4) evaluating the design [17]. However, in this manuscript we will not focus on the last two phases, as they are still in progress.

Phase 1: User Research (Identifying Requirements)
To understand the needs of elderly drivers, we conducted an online questionnaire with 26 participants (14 male) aged 51-67 years (M=58, SD=4.5). All have more than 15 years of driving experience. More than half drive daily and more than 90% drive more than 15 minutes each trip. The main driving purposes are business, commuting, shopping and visiting family and friends. While half of them mentioned no challenges encountered in driving tasks, the other half pointed out difficulties in seeing well, navigating and making instant decisions on the road. Many external risks were mentioned, such as bad weather conditions (darkness, twilight, rain, direct sunshine, ice) or oncoming or following vehicles' headlights. All are associated with impaired vision. Additionally, about 50% pointed out the increasing cognitive workload caused by misleading navigation information and distinguishing road signs and exit lanes in heavy traffic. These findings are consistent with the literature [23]. In contrast to the challenges, an unsatisfactory overall experience was confirmed by almost all participants, including the permanent need for concentration and quick reactions, distractions alternating with stress in intense or stop-and-go traffic, reckless or unexpected behavior of other road users, and road regulations in unfamiliar areas. Nevertheless, 65% had a fundamentally positive attitude towards driving, and nearly all expect AVs to solve the aforementioned challenges. Surprisingly, only 27% were certain in their plan to eventually purchase AVs, another 27% denied this explicitly, and the remaining 46% were unsure about their choices in the future. The reasons behind were mostly the immature technology development and an expected decrease of fun while driving. This is consistent with Hewitt et al. [10] who found a generally positive attitude towards AVs, along with increasing anxiety regarding higher degrees of autonomy. Most interesting was the fact that 81% claimed to have basic knowledge of AVs through various media (magazines, newspapers, television and word of mouth), but only 8% have personally experienced partial automated driving. As found by Furlan et al. [7], a comprehensive introduction of AVs and their functions in a study has a positive effect on older drivers' acceptance and trust in the technology. We therefore hypothesized that a user-centered AVs-simulation prototype which addresses the needs of the generation 50+ and immerses them in an automated driving situation, would improve their willingness of using the new technology.

Phase 2: Ideation & Storyboards (Building Altern. Designs)
We then invited six HCI experts to create and asses potential concepts for AVs building on the survey results. Using the method of insight combination [11] to achieve initial ideas, we presented all collected user needs, challenges, positive aspects of manual driving and expectations towards automated driving on yellow sticky notes. Blue sticky notes contained HCI patterns, tools and trends, e.g., "virtual reality". In multiple rounds two random sticky notes (one of each color) were assigned to all attendees. Then everyone recorded (on green notes) potential concepts combining the needs and patterns (yellow and blue notes) assigned to them. Afterwards, all green notes were sorted in a coordinate system (see Fig. 2). The vertical axis ranged from promising to bad ideas, the horizontal axis indicated unrealistic to feasible implementations. We only considered promising and feasible ideas (upper right quadrant) for further refinement. The focus group finally selected three concepts, each considering a different level of automation [20]. We then turned the rather vague concepts into three detailed storyboards (see Fig. 3). They are based on personas we created according to our target group. The first persona is a retired lady living in Munich,

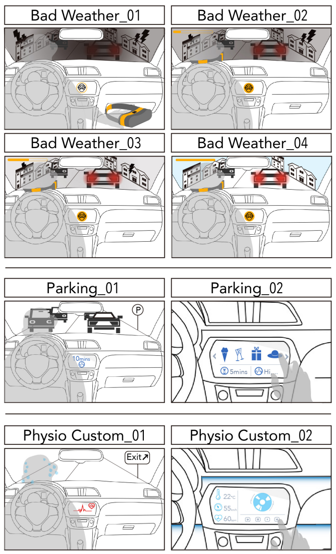

Figure 3: Storyboards of three concepts.

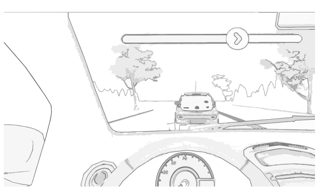

Figure 4: Sketch of VR prototype.

Germany. Her name is Elisabeth Koch, she is 65 years old and does not want to quit driving because of age-related impairments. The second persona is Yan Li, 56 years old and lives in Shanghai, China. She is a secretary, commutes to work daily and drives to a dancing class at least once a week. Her daughter introduced her to automated driving, which she finds interesting but still has several questions about.

Concept 1: Bad Weather, SAE level 3

Driving in bad weather escalates the impaired vision of aging drivers. We propose to use a head-mounted display with an augmented view of the surroundings. Drivers can select what they see: A storm, fog, other more distant road users, billboards and buildings can either be masked (to reduce visual clutter) or highlighted (to focus attention). In addition, the brightness can be adjusted, for example to brighten a dark environment. A scenario for this concept is: Ms. Koch drives in her level 3 vehicle during heavy fog. She is afraid to miss something due to constrained vision. Then she decides to use an HMD to virtually reduce the fog in her field of view and can continue the drive without anxiety.

Concept 2: Parking, SAE Level 4

Traffic congestions require of the continual concentration. We propose a parking mode on the central information display (CID), which distracts users from stop-and-go traffic and jams. Scenario: Ms. Li is waiting to enter a large parking space and has many vehicles in a line in front of her. When the system estimates a 10 minutes delay, the voice assistant in her car suggests content for this time. Ms. Li accepts and is given multiple activity options on the CID. She starts to browse interesting stores nearby. Suddenly, the CID tells her that the vehicle is parked and Ms. Li is happy to leave her vehicle.

Concept 3: Physiology Customization, SAE Level 5

To address the problem of increasing anxiety along with higher autonomy, i.e., level 5 in which we do not expect vehicle controls (e.g., steering wheel) as mandatory features. We propose to adapt a vehicle's interior (lighting, temperature, sound) and movements (intensity of acceleration or braking, top speed, velocity in curves) to physiological signals, such as the pupil diameter [18, 19], heart rate [2, 8] or galvanic skin response [5]. This implicitly creates a more pleasant UX. Scenario: Ms. Koch drives her AV out of town onto the highway. She is very excited to meet a friend she hasn't seen in years. Her heart rate increases and she starts sweating. The vehicle automatically adjusts the inside temperature and lighting, turns on calming music and avoids rapid acceleration. Ms. Koch continues her journey in a relaxed manner.

Phase 3 & 4: Prototype (Development and Evaluation)

We finally decided to build a prototype for Concept 1 as an immersive scenario in virtual reality and are currently iterating on the system design. A sample sketch is shown in Figure 4. Meanwhile, we are preparing for a user study with participants from the generation 50+. The evaluation includes a quantified UX questionnaire [12], a NASA-TLX assessment [9] for mental workload and a semi-structured interview [22] with participants.

Conclusion & Future Work

We present a research and design process with four main phases: (1) identifying requirements, (2) building alternative designs, (3) developing interactive designs, and (4) evaluating the design. We show insights and results from phases one to two and how they eventually form into a prototype. We currently modify and evaluate the prototype (phase 3 and 4 of the process) and will investigate whether such a system could influence participants' willingness to buy an AV. Furthermore, we will refine the prototype iteratively. At the conference, we hope to get feedback on our approach, in order to eventually turn the results into a full publication focused on the concepts.

REFERENCES

1. Hillary Abraham, Chaiwoo Lee, Samantha Brady, Craig Fitzgerald, Bruce Mehler, Bryan Reimer, and Joseph F Coughlin. 2017. Autonomous vehicles and alternatives to driving: trust, preferences, and effects of age. In *Proceedings of the Transportation Research Board 96th Annual Meeting (TRB'17)*.

2. S Akselrod, D Gordon, FA Ubel, DC Shannon, AC Berger, and RJ Cohen. 1981. Power spectrum analysis of heart rate fluctuation: a quantitative probe of beat-to-beat cardiovascular control. *Science* 213, 4504 (1981), 220–222.

3. Walter R Boot, Timothy A Nichols, Wendy A Rogers, and Arthur D Fisk. 2012. Design for aging. *Handbook of human factors and ergonomics* (2012), 1442–1471.

4. Rudi De Raedt and Ingrid Ponjaert-Kristoffersen. 2000. The relationship between cognitive/neuropsychological factors and car driving performance in older adults. *Journal of the American Geriatrics Society* 48, 12 (2000), 1664–1668.

5. A. de Santos Sierra, C. Sanchez Avila, J. Guerra Casanova, and G. Bailador del Pozo. 2011. A Stress-Detection System Based on Physiological Signals and Fuzzy Logic. *IEEE Transactions on Industrial Electronics* 58, 10 (Oct 2011), 4857–4865.

6. 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: http://dx.doi.org/10.1145/3239060.3239087

7. Andrea Furlan, Brenda Vrkljan, Hana Hussein Abbas, Jessica Babineau, Jennifer Campos, Shabnam Haghzare, Tara Kajaks, Margaret Tiong, Maria Vo, and Martin Lavalliere. 2018. The Impact of Advanced Vehicle Technologies on Older Driver Safety: A Scoping Review of Subjective Outcomes. In *Adjunct Proceedings of the 10th International Conference on Automotive User Interfaces and Interactive Vehicular Applications*. ACM, 186–191.

8. R. Gutierrez-Osuna and J. Choi. 2009. Using Heart Rate Monitors to Detect Mental Stress. In *2009 Workshop on Wearable & Implantable Body Sensor Networks (BSN 2009)(BSN)*, Vol. 00. 219–223.

9. Sandra G Hart. 2006. NASA-task load index (NASA-TLX); 20 years later. In *Proceedings of the human factors and ergonomics society annual meeting*, Vol. 50. Sage publications Sage CA: Los Angeles, CA, 904–908.

10. Charlie Hewitt, Ioannis Politis, Theocharis Amanatidis, and Advait Sarkar. 2019. Assessing Public Perception of Self-Driving Cars: the Autonomous Vehicle Acceptance Model. In *Conference on Intelligent User Interfaces (IUI'19)*.

11. Jon Kolko. 2012. *Wicked Problems: Problems Worth Solving: An introduction to wicked problems; 2. Skills for the social entrepreneur; 3. Teaching and learning; 4. Methods; Methods for conducting research and gaining empathy; Methods for synthesizing data and developing ideas; Methods for creating new designs; Methods for planning a business; 5. Conclusion*. Ac4d.

12. Florian Lachner, Philipp Naegelein, Robert Kowalski, Martin Spann, and Andreas Butz. 2016. Quantified ux: Towards a common organizational understanding of user experience. In *Proceedings of the 9th Nordic Conference on Human-Computer Interaction*. ACM, 56.

13. James L Malfetti and Darlene J Winter. 1986. Drivers 55 Plus: Test Your Own Performance. A Self-Rating Form of Questions, Facts and Suggestions for Safe Driving. (1986).

14. Anne-Sophie Melenhorst, Wendy A Rogers, and Evan C Caylor. 2001. The use of communication technologies by older adults: exploring the benefits from the user's perspective. In *Proceedings of the human factors and ergonomics society annual meeting*, Vol. 45. SAGE Publications Sage CA: Los Angeles, CA, 221–225.

15. William L Mihal and Gerald V Barrett. 1976. Individual differences in perceptual information processing and their relation to automobile accident involvement. *Journal of Applied Psychology* 61, 2 (1976), 229.

16. Charles Musselwhite. 2011. The importance of driving for older people and how the pain of driving cessation can be reduced. *Signpost: Journal of Dementia and Mental Health Care of Older People* 15, 3 (2011), 22–26.

17. Donald A Norman and Stephen W Draper. 1986. *User centered system design: New perspectives on human-computer interaction*. CRC Press.

18. Marco Pedrotti, Mohammad Ali Mirzaei, and Adrien Tedesco. 2014. Automatic stress classification with pupil diameter analysis. *International Journal of Human-Computer Interaction* 30, 3 (2014), 220–236.

19. Sohail Rafiqi, Chatchai Wangwiwattana, Jasmine Kim, Ephrem Fernandez, Suku Nair, and Eric C Larson. 2015. PupilWare: towards pervasive cognitive load measurement using commodity devices. In *Proc. PETRA*. ACM, 42.

20. Taxonomy SAE. 2019. Definitions for terms related to driving automation systems for on-road motor vehicles. *SAE Standard J3016* 3016 (2019).

21. Timothy A Salthouse. 1987. Adult age differences in integrative spatial ability. *Psychology and Aging* 2, 3 (1987), 254.

22. Tom Wengraf. 2001. *Qualitative research interviewing: Biographic narrative and semi-structured methods*. Sage.

23. J Yang and JF Coughlin. 2014. In-vehicle technology for self-driving cars: Advantages and challenges for aging drivers. *International Journal of Automotive Technology* 15, 2 (2014), 333–340.