Towards Life-Long Mobility: Accessible Transportation with Automation

Myounghoon Jeon
Mind Music Machine Laboratory
Cognitive and Learning Sciences
Computer Science
Michigan Technological University
Houghton, MI 49931, USA
mjeon@mtu.edu

Ioannis Politis
Engineering Design Centre
Department of Engineering
University of Cambridge
Cambridge, CB2 1PZ, UK
i.politis@eng.cam.ac.uk

Steven E. Shladover
California PATH Program
Institute of Transportation Studies
University of California at Berkeley
Richmond, CA 94804
steve@path.berkeley.edu

Christine Sutter
Ergonomics & System Design
Institute of Ergonomics & Human Factors
Mechanical Engineering
Technische Universität Darmstadt
Darmstadt, Germany
c.sutter@iad.tu-darmstadt.de

Jacques M. B. Terken
Section of User-Centered Engineering
Department of Industrial Design
Technische Universiteit Eindhoven
Eindhoven, The Netherlands
j.m.b.terken@tue.nl

Benjamin Poppinga
Smarttention Systems
Ingolstadt, Germany
bp@benjaminpoppinga.de

Automotive'UI 16 Adjunct, October 24-26, 2016, Ann Arbor, MI, USA
ACM 978-1-4503-4654-2/16/10.
http://dx.doi.org/10.1145/3004323.3004348

Abstract
Despite the prevalent discussions on automated vehicles, little research has been conducted with a focus on inclusiveness of traditionally excluded populations from driving. Even though we may envision a future where everyone can drive with perfect automation, the problem will not be that simple. As with any other problem domains, we need to scrutinize all the design considerations – not only each population's characteristics (capabilities and limitations), but also the entire system, technological limitations, and task environments. To this end, the present paper explores challenges and opportunities of automated vehicles for multiple populations, including people with various difficulties/disabilities, older adults, and children. This paper brings up some controversial points and is expected to promote lively discussions at the conference.

Author Keywords
Accessible computing; assistive technology; automated vehicles; inclusive design.

ACM Classification Keywords
H.5.2. [Information interfaces and presentation (e.g., HCI)]: User Interfaces; K.4.2 [Computers and Society]: Social Issues – assistive technologies for persons with disabilities

Introduction

From the Human Factors perspective, various research spaces on automated vehicles have been identified, including safety, fuel efficiency, trust, complacency, handovers of control, etc. [1]. Another critical point is "mobility improvement" for those who cannot easily drive: e.g., people with visual, auditory, cognitive or motor difficulties (less able to drive), disabilities preventing driving (not able to drive), older adults (gradually losing the ability to drive), and children (not allowed to drive). These populations have often been excluded [2] in the third wave of the "information revolution" (i.e., digital divide) [4]. We aim to “include” all these people in the future transportation system – this approach can be called accessible computing, assistive technology, or inclusive design. To this end, we attempt to explore the potential and challenges of automated vehicles so that these people would not experience an "automation divide" in the upcoming fourth wave of "AI or Automation" revolution era. After providing an overview of the design space and research agenda, we will specify considerations and opportunities for people with difficulties/disabilities, older adults, and children.

Design Custom: Compromise

Designers and engineers of modern vehicles are confronted with several external restrictions and requirements, e.g., maximum dimensions and weight, required safety equipment, or limitations on vehicle lighting characteristics. Still, their goal is to produce models that fit most of the customers. Thereby, they often seek to find a perfect compromise. For example, a driver's need for space to safely operate the car directly influences the available front legroom, while a truck's cabin size instantly affects the vehicle's cargo area. Today, most of these compromises are made with immediate and intended limitations for certain user groups, e.g., tall people will be unable to see everything on the instrument cluster, while small people will be unable to reach the pedals.

Increasing the diversity of users will further reduce the options for potential compromises and will have a huge effect on how the ergonomics and user interfaces can be designed. Luckily, technological trends support us in our idea to allow accessible transportation. Automation will reduce the importance of many of nowadays essential vehicle controls, such as the steering wheel or pedals. Further, an ongoing technical development will allow user interface concepts that are less tangible, but more versatile and dynamic (e.g., touch screens instead of physical knobs and buttons). Both aspects will create some room to consider accessibility as a new, essential design objective.

New Design Space

The first challenge for traditionally excluded populations begins with the level of automation - SAE J3016 [5]: whether our discussion on their involvement should start with Level 3 (occasionally requiring a driver to intervene on short notice to ensure safety when the system cannot manage the situation) or Level 4 (able to ensure safety within its operational design domain without the need for driver intervention)? Other than taking the appropriate level into account, the populations we focus on might be excluded from using Level 3 systems but they could potentially use Level 4 systems. A number of research questions arise at the same time, including “Will they need a type of free operation mode?”, “What if an emergency situation happens?”, “Do we have to implement an additional monitoring system, such as an operation management center or a remotely controlled system?", Or "May a type of tactical operation guidance (e.g., video conferencing) help?"

To discuss further, we can think of more specific scenarios. Even in the "fully automated vehicle" concept (Level 5), the situation could vary. For example, on the one hand, vehicle users still "have to" be involved in the loop in case of emergency or because of legal requirements. On the other hand, vehicle users still may "want to" be involved in the loop even though it is not necessary. In either case, an inclusive design approach leads to important research questions.

1) In the "have to" be involved case, are these populations able (or allowed) to be in the loop? It is rather a "hard" problem because it would require vehicle users to be involved in the "maneuvering" level (e.g., blind people or older adults for lateral control when sensors for road markings fail) and/or in the "control" level (e.g., children or people with mobility disabilities for accelerating/braking when the auto-cruise control fails).

2) In the "want to" be involved case, these people do not need to be engaged in the loop, but they can just ride or be transported in a "train-like" concept. Another possibility is that they want to be in the loop, which asks the system to be polite [6] enough to accept the vehicle user's engagement even in the non-necessary case. Then, we need to consider how they could/should/would be involved in the process; whether it is just passive involvement, such as being provided with consistent situation updates or it is more active involvement in which they interact with their vehicle, by negotiating and making joint decisions. As discussed, this inclusive approach requires more fundamental questions to be answered about the automation concept as well as what type of user interfaces, with which modalities we design for them. It also raises difficult questions about arbitration in situations in which the vehicle user and the automation system disagree about the existence or severity of a hazard – who has the final say over the vehicle motions? Should a vehicle automation system be designed with the authority to override a human judgment? It seems to involve ethical issues as well. Moreover, this inclusive design approach is expected to provide a more comprehensive perspective to prepare futuristic automation services, which will also result in better system design for traditional drivers as well.

Pilot System: Low Speed Urban Shuttle

This type of approach is not totally new. There have been attempts to field test low-speed shuttle systems in medium-density urban and campus environments to provide improved mobility for short-distance trips and for "first mile/last mile access" to and from conventional public transit services. Given the immaturity of the available vehicle automation technology, these systems require careful integration with the public infrastructure including modifications to restrict the hazards that the vehicles need to confront, and their speeds are severely limited. They still require onboard human supervisors to manage the traffic complexities that the automation systems cannot handle themselves, and they are still subject to false alarm stops. Over time, the technologies are likely to mature to the point that the speeds can be higher, the infrastructure less protected and the supervisors unnecessary. However, there are still challenges to manage associated with the personal security of vulnerable travelers against petty crime when there is no authority figure supervising the vehicle, as well as challenges of vehicle access and navigation to destinations for the less capable travelers.

People with Difficulties / Disabilities

Inclusive design [2, 3] refers to a product design practice that assumes a diverse user group in terms of capabilities. The polarized view of the population as either being “able-bodied” or “disabled” can limit the opportunities to design for users who would not identify themselves with any of the above groups. Inclusive design takes into account that difficulties can be present in everyday activities; these can range from capabilities related to hearing or vision, cognition (for example, memory or thinking), communication, mobility and dexterity. These difficulties can have different levels of severity, and still not lead to the person being self-identified as “disabled”. This design approach attempts to provide concrete measures for detecting the difficulties induced by using a product[1] and embed these considerations in the whole product lifecycle. Automated vehicles are a technology which, although not new, has recently reached high popularity. Therefore, there is an exciting opportunity to utilize an inclusive design thinking as early as possible in its development. This challenge is currently being addressed by the HI:DAVe project[2] in University of Cambridge, in cooperation with University of Southampton. Designing inclusive interfaces for automated vehicles is an exercise that is expected to address the diversity of the population in this promising mode of transportation.

Older Adults

While for user groups such as children and blind people Level 3 automation, where the vehicle can drive automatically in some situations (e.g., the highway) but not in other situations (e.g. urban environments), is definitely out of reach, for elderly drivers (75 years and over) Level 3 may already be an attractive value proposition. Given that Level 5 automation in urban environments still has a long way to go, excluding elderly drivers from Level 3 automation will seriously affect their mobility for the next decades. Set off against the fact that mobility is an important contributor to perceived quality of life, we should consider opportunities to make automated driving (including Level 3 automated driving) accessible to elderly users. However, Level 3 automated driving poses two types of challenges (while the first type is applicable to Levels 4 and 5 automated driving as well):

(1) During phases where the vehicle drives automatically, elderly users (like other users) will face issues of trust and acceptance. This creates a need for technology developers to develop systems that support trust formation [e.g., 7]. Questions here concern how we can provide information to elderly drivers to develop a proper understanding of the system, so that for instance people will not intervene when it is not needed. Also, questions arise as to the desired

1 See for example http://www.inclusivedesigntoolkit.com/betterdesign2/exclusioncalc/exclusioncalc.html

2 https://www.epsrc.ac.uk/newsevents/news/jlrannouncesautonomousvehicalresearchprogramme/

behaviour of automated vehicles for elderly people. Will all automated vehicles display the same standard behaviour, or is it possible to tune behavioural characteristics such as driving style [8] and politeness to the needs and interests of elderly drivers. And in either case: what are the consequences?

(2) During phases where the vehicle does not drive automatically, elderly drivers will need special assistance to drive safely and be able to face the challenges of modern traffic. This creates a need to tune existing and future driver assistance systems to the needs of elderly drivers [9], and to investigate whether such elderly-proof ADAS make it possible to ensure a safe situation, both for the occupants and other road users.

Children

Fully automated vehicles might open up access to cars for everyone, even to underage children traveling unattended. In future, it might be possible for children to cover their way to and from (pre-) school, to social and hobby activities, and to meet their friends in fully automated vehicles, without the presence of an older person to supervise and ensure their safety (this is at present a legal requirement). For underage children traveling unattended, the vehicle’s service and design needs to substitute for the not-present adult in order to ensure that children are safely tucked into the vehicle and remain safely in the vehicle during traveling time to prevent them from any harm or doing mischief. Specific remote services (surveillance or emergency call) might be necessary when children want to talk to an adult or in case of distress. To pick up children traveling unattended, the questions arise of who will be allowed to access the vehicle and who checks that the adult is authorized to do so.

Practical Outlook

We think that there will be several themes for vehicles in the near future. These themes span and influence the physical interior and the overall interaction concept. Thereby, the vehicle will be able to fully adapt the user's very individual needs. For example, we can imagine a theme that is designed for office purposes, which comes with targeted interaction concepts to increase productivity. Further, we think there will be a theme with rather playful experiences, if children and their entertainment are the primary objective. Finally, we envision a theme that compensates for a traveller's difficulties/disabilities, e.g., by offering all information in the most suitable modality or by adapting the ergonomics to be as operable as possible.

Conclusion

In the present paper, we explored a variety of aspects of automated vehicles about inclusiveness. Some of our prospect will trigger arguments, but this will serve as a good starting point about how to embrace diverse individuals in automated driving. As shown, some issues might be solved by the introduction of fully automated vehicle services in the distant future. Depending on the characteristics of drivers, however, all the concrete implementation procedures for intermediate automation levels should be further specified. In conclusion, the future of automated transportation for traditionally excluded populations seems to be promising. The present paper only slightly touches the topic, whereas more in-depth studies and empirical research for each population should be followed. We hope that in the future nobody would be excluded and everyone can enjoy automated transportation whenever and wherever, and that the present paper can provoke lively discussions on this topic.

Acknowledgements

This paper is partly based on discussions with participants of the Dagstuhl Seminar 16262 “Automotive User Interfaces in the Age of Automation“, http://www.dagstuhl.de/16262.

References

1. K. Weir, “The psychology behind self-driving cars: Along for the ride,” Monitor on Psychology, vol. 46, no. 1, pp. 60-65, 2015.
2. S. Keates, & J. Clarkson, "Inclusive Design". London, UK: Springer, 2003.
3. P. Langdon, D. Johnson, F. Huppert, & P. J. Clarkson, "A framework for collecting inclusive design data for the UK population," Applied Ergonomics, 46, 318-324, 2015.
4. A. F. Newell, "Accessible computing: Past trends and future suggestions," ACM Transactions on Accessible Computing, vol. 1, no. 2, pp. 9:1-7, 2008.
5. SAE J3016_201401. "Taxonomy and Definitions for Terms Related to On-Road Motor Vehicle Automated Driving Systems," 2014.
6. E. Arroyo, S. Sullivan, & T. Selker, "CarCoach: A polite and effective driving coach," CHI'06 Extended Abstracts on Human Factors in Computing Systems. ACM, 2006.
7. A. Mirnig, C. Sutter, P. Wintersberger, & J. Ziegler, “A framework for analyzing and calibrating trust in automated vehicles,” Automotive UI 2016, Work in Progress,(submitted).
8. H. H. van Huysduynen, J. M. B. Terken, J. B. O. S. Martens, & J. H. Eggen, "Measuring driving styles: A validation of the multidimensional driving style inventory," In Proceedings of 7th International Conference on Automotive User Interfaces and Interactive Vehicular Applications, Nottingham, UK. 2015.
9. R. Robertson, & W. Vanlaar, “Elderly drivers: future challenges?” Accident Analysis and Prevention, vol. 40, pp. 1982-1986, 2008.