Designing a Naturalistic In-Car Tutor System for the Initial Use of Partially Automated Cars: Taking Inspiration from Driving Instructors

Anika Boelhouwer
University of Twente,
Enschede, The Netherlands
a.boelhouwer@utwente.nl

Marieke Martens
University of Twente,
Enschede, The Netherlands
m.h.martens@twente.nl

Arie Paul van den Beukel
University of Twente,
Enschede, The Netherlands
a.p.vandenbeukel@utwente.nl

Mascha van der Voort
University of Twente,
Enschede, The Netherlands
m.c.vandervoort@utwente.nl

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

ACM ISBN 978-1-4503-6920-6/19/09.
https://doi.org/10.1145/3349263.3351504

Abstract
As commercial cars start to include more automated functions it becomes difficult for drivers to understand how and when to use them safely. While general HMI recommendations for partially automated cars have been made, it is unclear how drivers should be supported during the initial use period. Recommendations for a tutor system that guides drivers in their initial use of partially automated cars are necessary. To gain inspiration for such a tutor system, we examined the existing communication loop of driving instructors and their students. Driving instructors and their students were video recorded during regular driving lessons. The tutoring patterns that were found (i.e. situation and student adaptive feedback, student adaptive tasks, body movements for correcting and requesting actions) during the initial qualitative analysis are discussed. Furthermore, we suggest methods how to implement the tutoring patterns in a tutor system to support drivers in the use partially automated cars.

Author Keywords
Automated driving; feedback; tutorial; observation study.

CCS Concepts

• Human-centered computing~Field studies

Introduction

With the introduction of partially automated cars in the consumer market, the driver's role shifts gradually from physical operator to supervisor [8]. In the currently available SAE level 2 systems [10] drivers have to monitor the system continuously and decide when it is necessary to take back control. Still, even systems up and including level 4 require drivers to take back control occasionally. It can be very challenging for drivers to know exactly what automated systems are in their car, in which conditions these can safely operate and when it is necessary to take back control [4,7,11]. Even when drivers have a theoretical understanding of the systems before driving, the recent study by Boelhouwer et al. [3] showed that it is difficult to apply this theoretical knowledge in real-word driving situations.

It is proposed that an in-car tutor system may help drivers in their new role. An in-car tutor system may not only give drivers an initial understanding of the systems but also guide drivers over a prolonged period of time. This will further strengthen their knowledge and skills, but also keep the information up-to-date with any over-the-air automation updates [2,6,9]. Furthermore, an in-car tutor system may be able to give specific and live feedback on real life driving situations. For example: the car may have difficulties driving in highly dense traffic areas and recognizes such a situation coming up. It may then inform the driver about the situation, suggest actions and discuss similar other situations. While studies like that by Beggiato et al. [1] provide a clear general base for automated car HMI as requested by drivers and experts, it remains unclear how drivers should be supported when learning to use the system and during the initial driving period.

Our study examined the natural communication between driving instructors and their students as an inspiration for a *naturalistic tutor system* in partially automated cars. This particular communication was chosen as it resembles a very similar dynamic as one would see between a tutor system and driver. In both situations, the driver needs to learn about and practice using a car (system). In our case the tutor system takes the role of the driving instructor. The tutor system will teach the driver about the automation in the car and when and how to use it safely. Experienced driving instructors and their students were video recorded during their normal driving lessons. Not only the behavioral and verbal feedback by the instructors were studied, but also the driving situation and environment in which they took place. This work-in-progress paper presents the first tutoring patterns found during the driving instructor observations. After this initial analysis, further quantitative analysis will be performed to identify tutoring patterns and especially how they are adaptive to the student driver, instructor and driving situation.

Method

Participants

During this study we video recorded a total of 17.5 hours of driving lessons in The Netherlands with 8 driving instructors (7 male, 1 female) and 16 driving students (11 male, 5 female). The average age of the instructors was 52 years (*SD* = 10.8, min=33, max=61). The teaching experience ranged from 1 to 40 years, with an average teaching experience of 19 years (*SD* = 14.4). The driving students were on average 19 years old (*SD* = 2.2, min=17, max=24). The driving student needed to

Figure 1: An example of the combined observation videos.

have completed at least 5 driving lessons in order to participate. This was required to avoid additional pressure on the often already nervous new driving students. On average, the driving students had 27 lessons of experience at the start of the experience (*SD* = 13.3, min=5, max=53). All participants signed an informed consent and agreed to be video recorded.

Materials and set-up

Two GoPro Hero4 cameras were mounted in the driving lesson car. Both cameras were placed on the dashboard, with one facing outside and the other facing inside the car. This way, both the driving environment and persons inside the car could be captured simultaneously. The videos were later synchronized and combined as shown in figure 1. The instructors were asked to include both urban, rural and highway situations in the lesson. During the lessons, an experimenter was seated in the back of the car to take notes of the instructor-student communication.

Variables

Three key variables in the videos were marked and categorized: behaviour of the instructor, speech of the instructor and the driving environment. While the detailed categorization and analysis of these elements is too lengthy to discuss in this paper, it is good to know that the driving environments were divided based on prior studies in low, medium and high complexity situations [5]. Furthermore, all speech was transcripted. This initial analysis identified tutor patterns through recurring behaviour and speech events and short structured interviews with the instructors at the end of the driving sessions. These included questions on how they adapted their feedback to the students and the environment.

Results

Student adaptive task

Multiple instructors adapted their route to the skill level of the students. More explicitly, instructors guided students towards areas that included situations that the student struggled with. For example, a student that had difficulty with downshifting and sharp curves was directed towards a residential area with multiple consecutive roundabouts to practice these specific skills.

Student adaptive feedback

The instructors adapted their feedback to the skill level of the student in multiple ways. First, inexperienced students were often instructed about complex situations before they occurred, sometimes even letting the student fully stop to first explain the situation. However, instructors would often let more experienced students first experience a complex situation before explaining them. After letting the student stop they would explain the situation and sometimes ask the student to reflect on their actions and identify any errors. Second, the instructors’ feedback usually started out more elaborative and consisted of both speech and gestures at the start of the lesson. As time progressed, the feedback reduced in detail and either speech or gestures were omitted. Only when the same error was made repetitively, instructors would start elaborating again and sometimes point out a similar situation as it approached.

Situation adaptive feedback

Low complexity situations appeared to give more room for reflective discussions and social bonding, while highly complex situations appeared to elicited shorter and more action oriented feedback. Also, instructors explicitly stated any out of the ordinary situations and how that may affect the traffic and actions needed.

Correcting and requesting actions

Gestures and bodily movements were often used to amplify a message or request an action. Exaggerated looking over the shoulder by the instructors was observed if the students did not look properly. Smooth hand- or body movements were used to ask the student to slow down. In case of a demanding or critical situation that required full attention, the instructors would seize al verbal communication, sit stiffly upright and raise either their hand or finger.

Inspiration for an in-car tutor system

During the training phase, it may be advisable to identify the driver's understanding of the automation. Then, any situations the driver struggles with may be practiced more often, either through real life rerouting or through simulation. During uncomplicated situations the tutor system may take the opportunity to include more elaborative feedback on what the car is doing and why the car is taking a particular action to support learning. This may be complemented through multiple modalities to stimulate engagement and learning. As the user gains experience, the feedback may become less elaborate and reduce in modalities. As recurring unnecessary or unsafe take-overs have been detected, the system may announce and explain similar upcoming situations. The timing of feedback during training may also need to be different for users with more or less experience with the automation. Inexperienced users may require more information before practicing certain situations, while experienced users may benefit more from experiencing the situation first and then discussing it. Furthermore, the system may discuss any abnormalities in the driving situation and how this may affect the cars driving behaviour. For example: "The visibility through my cameras is very poor, therefore I am driving at a reduced speed".

Conclusion and future work

During this study, we looked at tutoring patterns between driving instructors and their students and how we may use these for a tutor system in partially automated cars. This tutor system will support drivers in learning about the automation in their car and how to safely use it. The type, length and timing of the communication all appeared to adapt to both the student's skills and to the driving environment. Not only the communication but also the tasks and chosen route seemed to be based on the skill level of the student. Furthermore, both full body and small gestures were used to request or correct actions of the student. In our future analysis we will quantitatively examine how the feedback of instructors is adaptive to the driving environment and the student's skill level. This will allow us to create an extensive list of recommendations for an in-car tutor system to support drivers in understanding and using partially automated cars. Then, several in-car tutor prototypes will be developed and tested in our driving simulator with potential future users of partially automated cars.

Acknowledgements

This research is supported by the Dutch Domain Applied and Engineering Sciences, which is part of the Netherlands Organization for Scientific Research (NWO), and which is partly funded by the Ministry of Economic Affairs (project number 14896).

REFERENCES

1. Matthias Beggiato, Franziska Hartwich, Katja Schleinitz, Josef F. Krems, Ina Othersen, and Ina Petermann-Stock. 2015. What would drivers like to know during automated driving? Information needs at different levels of automation. In *7thConference on Driver Assistance*. https://doi.org/10.13140/RG.2.1.2462.6007
2. Matthias Beggiato and Josef F. Krems. 2013. The evolution of mental model, trust and acceptance of adaptive cruise control in relation to initial information. *Transportation Research Part F: Traffic Psychology and Behaviour* 18: 47–57. https://doi.org/10.1016/j.trf.2012.12.006
3. Anika Boelhouwer, Arie P. van den Beukel, Mascha C. van der Voort, and Marieke H. Martens. 2019. Should I take over? Does system knowledge help drivers in making take-over decisions while driving a partially automated car? *Transportation Research Part F: Traffic Psychology and Behaviour* 60: 669–684. https://doi.org/10.1016/j.trf.2018.11.016
4. Oliver Carsten and Marieke H. Martens. 2018. How can humans understand their automated cars ? HMI principles , problems and solutions. *Cognition, Technology & Work*: 1–18. https://doi.org/10.1007/s10111-018-0484-0
5. Wolfgang Fastenmeier. 1995. Die Verkehrssituation als Analyseeinheit im Verkehrssystem. *Autofahrer und Verkehrssituation - Neue Wege zur Bewertung von Sicherheit und Zuverlässigkeit moderner Straßenverkehrssysteme*: 27–82.
6. Walter Kintsch. 1998. *Comprehension: A paradigm for cognition.* Cambridge University Press, New York, NY. Retrieved May 12, 2019 from https://bit.ly/2Z7Abl6
7. Marieke H. Martens and Arie P. van den Beukel. 2013. The road to automated driving: Dual mode and human factors considerations. In *IEEE Conference on Intelligent Transportation Systems*, 2262–2267. https://doi.org/10.1109/ITSC.2013.6728564
8. Markus Maurer, J. Christian Gerdes, Barbara Lenz, and Hermann Winner. 2016. *Autonomous Driving: Technical, Legal and Social Aspects*. https://doi.org/10.1007/978-3-662-48847-8
9. William Payre, Julien Cestac, Nguyen Thong Dang, Fabrice Vienne, and Patricia Delhomme. 2017. Impact of training and in-vehicle task performance on manual control recovery in an automated car. *Transportation Research Part F: Traffic Psychology and Behaviour*: 216–227. https://doi.org/10.1016/j.trf.2017.02.001
10. SAE International. 2016. *Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles*. Retrieved May 12, 2019 from http://standards.sae.org/j3016_201609/
11. Mehdi Saffarian, Joost C. F. De Winter, and Riender Happee. 2012. Automated Driving: Human-Factors Issues and Design Solutions. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting* 56: 2296–2300. https://doi.org/10.1177/1071181312561483