Workshop on Human-Vehicle-Environment Cooperation in Automated driving: The Next Stage of a Classic Topic

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ABSTRACT

It appears that autonomous systems are replacing human in the driving task. However, autonomous driving abilities do not mean that vehicles should not interact with their drivers/passengers or their environment anymore. There are still many scenarios where either the automated system cannot handle the driving very well, or human wants to spontaneously influence the behavior of the system to meet their preferences. Thus, beyond the hype of autonomous driving, a large space opens for human-vehicle cooperation at a different level of automated driving. As this topic draws more attention both by academia and industry, we organize this workshop to in-depth identify potential research opportunities of it under the latest technology of automated driving. In this workshop, participants will discuss the motivations of driver/passenger's intervention, generate the use cases of cooperative driving, and explore means of cooperation and interaction that human and vehicle would exchange intent smoothly. It is expected that the workshop will consolidate existing knowledge of human-vehicle-environment cooperation and provide insight for future works.

CCS CONCEPTS

• **Human-centered computing → HCI theory, concepts and models**.

KEYWORDS

Human-vehicle cooperation, Cooperative driving, Automated driving

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1 INTRODUCTION

Numerous autonomous driving engineers are working on replacing human with systems, and even SAE International defines high-level automation (Level 3,4,5) as drivers "are not driving when these automated driving features are engaged" [7]. The engineering-oriented research and implantation produce an impression that people do not want/need to cooperate with the system anymore. However, there are still many scenarios where either the technical system requires human's intervention, or human wants to spontaneously influence the behavior of the automated driving system: On one hand, the system cannot deal with many situations, which may lead to uncomfortable/danger to situation. Even if there are no safety-related issues (e.g., in level 4-5 automation), the driving style of system may meet the current preference of the passengers [10][11]. The examples are when the driver would like to reduce the distance from the front car and would not like to follow a big truck. On the other hand, for more than one hundred years, vehicles fulfil our basic needs of our own autonomy and freedom, which will not disappear with autonomous driving. These scenarios include pulling over to enjoy the view and selecting a parking lot etc.

One option for address the problem is human-machine cooperation [1], which is not a new concept. [2] describe the relationship of rider and horse as design metaphor for human-vehicle cooperation with different modes of automation, which were translated from H-Metaphor to the engineering community as assisted, semi- and highly automated driving [4], structured by a group led by German BASt into four [3], and later extended by SAE to five levels of driving automation. However, for a couple of years, human-vehicle cooperation got less attention in the automotive UI community. The reason may be that the rapid development of AI creates an illusion

that fully autonomous driving will be commercialized soon. Unfortunately, after real-world implementation and testing, researchers and practitioners realize that AI still need many years to deal with numerous corner cases, and human guidance is a potential solution [8]. Besides, the latest technology of interaction (e.g., gaze- and brain-interface) makes seamlessly exchanging intentions between the system and human become possible.

As a result, the topic of cooperative driving ushered in a revival. For example, Walch et al. [9] proposed a system that allows the driver to overcome the vehicle's obstructed sensor range in 2019. Holländer et al. suggested interface concepts enabling driver participation in the decision-making of the driving system, increasing the joy of driving in 2020 [13]. Later, Wang et al. introduced prediction-level guidance to an automated driving system through gaze-speech interaction [11][12]. Meanwhile, a series of national and international projects focusing on this topic, e.g., the German "Cooperatively interacting vehicles" [6] and EU-projects HADRIAN [5], were granted.

Therefore, we want to organize a workshop to revisit this topic under this background to find out the fundamental motivation of human-vehicle cooperation, which scenarios are necessary for cooperation (and the interaction technique human and vehicle can cooperate smoothly. It is anticipated that revisiting this topic through a workshop would shine new light on the value of human-vehicle cooperation in this new era.

2 PARTICIPANTS, TOPICS AND GOALS

It is expected that the further development of the topic requires deeper confluence between the system and the human's mind. Thus, we want to invite experts both from the automated system domain, such as autonomous-driving researcher, automotive engineers and sensor specialist; as well as human's perspective, such as human-machine interaction researchers, psychologist and user experience designers.

In this workshop, three topics will be discussed to have a holistic view on this topic:

- **Why** does the human driver want/need to intervene in the cooperative system?
  The necessity of human driver's involvement remains controversial, especially among automated driving engineers. Therefore, it is necessary to discuss the fundamental motivation to conduct cooperative driving, thus, researchers will have a base for further investigation in this direction.
- **Which** scenarios are appropriate for human-vehicle cooperation?
  The cooperation need not happen in all locations or scenarios as most of the time a qualified automated system should drive by itself. It is necessary to find out the typical use scenarios in which the system either the system or the human intent to cooperate.
- **By which** interaction means can human driver and vehicle accomplish the cooperation?
  Normally, an automated vehicle moves fast on the road, which leaves a limited time window for human driver/passenger and the system to exchange their intent, negotiate to meet an agreement of what action will be taken next. The novel interaction technologies, such as gaze-, speech- or brain-interaction will be discussed associated with the use cases.

The workshop outcomes may provide researchers and practitioners in the automated driving domain a new insight on the direction of cooperative driving, encourage them to further explore its potential and open a new research area of the Automotive UI community.

3 SECTIONS AND OUTCOMES

We expect to conduct two separate workshop sessions with experts from different time zones. The workshop is structured to address all three before mentioned topics of "Why", "Which" and "By which interaction means" in five consecutive sections. The first workshop section starts with the workshop motivation and a short impulse on the reason for cooperation. The motivation leads to section two, which addresses the topic of "Why" and "Which" in the form of a discussion in small groups. Followed by section three, where participants will meet with another group to further discuss and work on use cases for cooperation. Later, they come back into their own group to develop an interaction design for at least one of these use cases to later, in section five, present to other groups, "by which interaction means" the use cases can be solved. The last part is reserved for a wrap up of the workshop. As a total time budget, 90 minutes plus 5 minutes break are planned for the workshop.

In addition to the workshop, the organizers provide a website with information about the topic for participants to be able to get in touch with the topic prior to the workshop. During the workshop, we will use Zoom and Miro (see Figure 1) for presentations and brainstorming, respectively.

3.1 Welcoming and introductory section

The workshop host will welcome the participants and give an introduction to the schedule as well as the motivation for this workshop. (5 minutes)

To kick-off the productive phase of the workshop, two expert presenters will give an impulse presentation of seven minutes each on their understanding of what cooperation is and why we need it. The presentations should give a quick overview selected topics of past and current research, then motivate the upcoming workshop phases. (15 minutes; 20 minutes total)

3.2 Why is cooperation needed and which scenarios are appropriate?

In different levels of automation (according to SAE [7]) and different phases of conducting automated driving, the purpose of the cooperation is various. For smaller automation levels, it might be safety-related to prevent life-threatening situations. For higher automated vehicles, however, the purpose of cooperation would change in the direction of comfort, letting the human relax while still offering the opportunity of involvement in the driving task. Taking it further, for a highly or fully automated vehicle, cooperation can aim to increase productivity of the driver, enabling her or him to safely shift the focus on a nondriving related task. Beginning with this phase, we start dividing all participants into small groups of three participants. We first start with a few minutes to break the ice and get to know each other before further discussing the

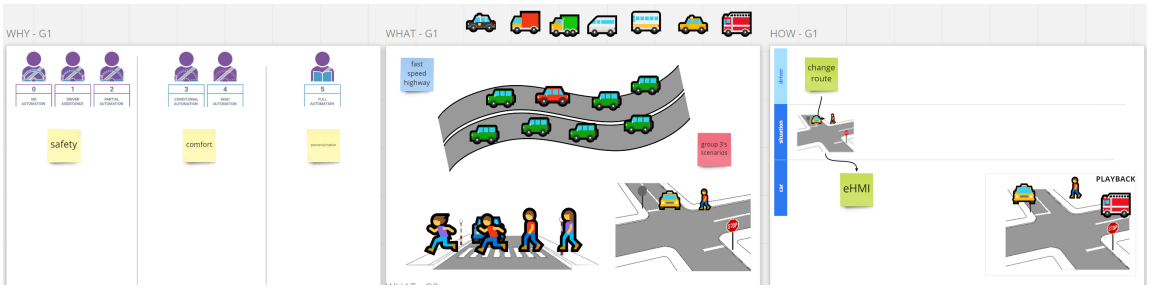

Figure 1: The outline of the workshop follows "Why", "What", and "How" as illustrated in the Miro boards.

topic of "Why is cooperation needed?" Most important results are documented on the miro board in form of post-its. (10 minutes)

From crowded urban area to fast-speed highway, cooperation fits in many scenarios. The groups that formed beforehand will further discuss potential cooperation use cases ranging across all automation levels, traffic types (e.g. heavy or low traffic on a highway or rural roads, urban rush hour, …), environmental conditions (e.g. heavy rain, bright sunlight, damaged streets or road works, …), etc. All discussed use cases are documented on the Miro board in the form of a small visual and/or textual scenario description. In addition, presenters of 3.2 have provided one use case based on their presentation beforehand as examples and starting points for the group discussions. (10 minutes; plus a 5-minute break at the end for a total of 25 minutes)

3.3 How is cooperation designed in these use cases?

In different conditions, the workload of human and reaction time are quite various. Expectations of the driver and how the car should react might vary as well.

For a timeframe of about seven minutes, groups are merged and examples of the results of 3.2 ("Why" and "Which" sections) are discussed. Afterwards, participants re-gather in their former groups and work on the objective to create an interaction design for at least one example scenario and document it on a prepared Miro frame. This includes a graphical representation of the designed interaction (swim lane diagram) to be able to give a short presentation to other groups in the next workshop phase.

All tools necessary for the collaborative design in Miro and for the visual situation representation are provided. Participants can include their own figures easily, but do not need to. (30 minutes)

3.4 Wrap up and evaluation section

Each group gives short presentation of their interaction design with focus on the most important aspects of their design based on the documented graphical representation as well as their understanding of why cooperation is needed in the presented scenario (three minutes per group plus two minutes discussion). Depending on the number of participants, this takes place either in the plenum or in combined groups. (15 minutes)

As evaluation of the workshop, everybody answers two questions and pins their answers to the prepared miro frame:

- Which single aspect of what I learned today do I see as important and want to point out?
- Which aspect received less attention than it deserves?

After answering, the participants have time to read the others' feedbacks. The moderator wraps up the workshop and gives the opportunity for further discussion after the workshop, all based on available time and interest of the participants. After the workshop, its results are documented on the website as well, for all participants and others to revisit the designs (as far as legally possible). (5 minutes; 20 minutes total)

4 ORGANIZERS

Chao Wang works as a senior scientist at Honda Research Institute Europe. He received a PhD degree from the Eindhoven University of Technology in 2017. His research focuses on HCI of automated driving, human-robot interaction and explainable artificial intelligence.

Marcel Usai is a Ph.D. student and research assistant at the department of Human Systems Integration at the RWTH Aachen University. His research focuses on the realization of intuitive human-machine cooperation through design and observation of interaction pattern.

Jingyi Li is a Ph.D. student in Media Informatics at the University of Munich. Her research focuses on the safety and comfort of the rear-seat passenger in their use of interactive technologies in the confined space of the car.

Martin Baumann is a professor and the chair for Human Factor at Ulm University. His research interests are Cognitive Modeling, Human-Machine-Interaction and -Cooperation, Comprehension processes and mental representation. He serves as the co-chair at AutoUI2021.

Frank Flemisch is a professor for Human Systems Integration at the RWTH Aachen University and a branch head for balanced Human Systems Integration at Fraunhofer. He is stunned that after 30 years of research on highly automated and cooperative driving, there is still a lot to discover, that the best time of the cooperation paradigm is yet to come, and that the best automotive user interfaces and concepts are yet to be invented and developed.

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