Human Vehicle Interaction Model for Supervision in Conditionally Automated Driving Cars

Marine Capallera[a], Leonardo Angelini[a], Omar Abou Khaled[a] and Elena Mugellini[a]

[a] *HumanTech Institute, HES-SO//University of Applied Sciences Western Switzerland, Fribourg, Switzerland*

Abstract

Developments in the field of semi-autonomous driving will increasingly free the driver from the main driving task. Conditional autonomous driving allows the driver not to constantly monitor her/his environment, but s/he must still be able to regain control of the vehicle at any time if the situation requires it. That's why it is important to maintain driver's Situation Awareness while is performing a secondary task. This paper presents a model of an adaptive, full-body and multimodal Human Vehicle Interaction (HVI) for supervision.

Keywords

Conditionally automated driving, Human-Vehicle Interaction (HVI), Situation Awareness, Supervision, Multimodality, Peripheral interaction

1. Introduction

1.1. Context

Recent developments in automotive field tend more and more to support the driver in different driving related tasks. For example, current Tesla autopilot frees the driver from acceleration and steering controls but s/he still has to remain engaged with the environment monitoring and driving task (keep hands on the steering wheel). The Society of Automotive Engineers (SAE) [1] classifies this automation level as Level 2 vehicles. Level 3 vehicles, or conditionally automated vehicles, are more challenging because the driver will not be required to monitor the environment but s/he still has to be able to take over control of the vehicle at any time if necessary. This leads to an important change in the driver's role from actor to supervisor. In addition, the driver will be allowed to perform a non-driving related task. Moreover, because the driver and the automation will collaboratively and interactively control the vehicle (shared control), we can see the car as a companion that the driver should be able to trust.

1.2. Problematic

If the driver is engaged in a secondary task, s/he will be out of the control loop and a return to manual driving will be more difficult because it will require a higher cognitive load [2]. That's

Proceedings of ETIS 2020, November 16–20, 2020, Siena, Italy
marine.capallera@hes-so.ch (M. Capallera); leonardo.angelini@hes-so.ch (L. Angelini); omar.aboukhaled@hes-so.ch (O.A. Khaled); elena.mugellini@hes-so.ch (E. Mugellini)

Table 1
Concept Descriptions

Concepts	Interaction	Location	Conveyed information
Haptic seat	Haptic (vibrations)	Backrest and pan	Obstacle around the car Lane marking degradation
Overlay application	Visual (and auditory)	Personal device	Information & alerts nearby environment
Conversional agent and ambient lights	Visual and vocal	Vehicle's interior	Environment condition Car status

why it is important to:

- Keep the driver aware of her/his environment when performing non-driving related task in order to reduce her/his cognitive workload during disengagement.
- Take the driver state (stress, drowsiness) into account in order to adapt the interaction.
- Design peripheral interactions that are performed on peripheral attention in order to maintain the driver into the loop [3], while s/he is engaged in non-driving related tasks.

2. Objective

The objective of our work is to design a full-body and multisensory experiences by considering the whole car interior and peripheral interaction in order to support driver supervision task and increase situational awareness. The objective is to find a combination of modalities of interaction that should adapt to the environment and the automation state. The choice of combination may also depend on the driver's state in a second step. The second objective of this concept is to convey information about the vehicle information to the driver in order to increase her/his trust to the system. Thus, vehicle's actions may not match driver's expectations in some situations. That is why transparency should be taken into account [4].

3. Conception

The model of adaptive, full-body and multimodal Human Vehicle Interaction (HVI) for supervision presented in Figure 1 combines haptic interaction (vibration in seat), visual interactions (ambient lights and split-screen application) and vocal interaction (conversational agent). This HVI conveyed information to the driver about her/his environment through different modalities and part of the car. The various reflections on the design of these concepts are described below and in Table 1:

- **Haptic seat:** Because driver may no longer have her/his hands on steering wheel and will look away from the road the seat seems promising for transmitting information through haptic interactions [5, 6].
  Hypothesis: it may provide the driver with a more complete peripheral and extended vision of her/his environment [7].

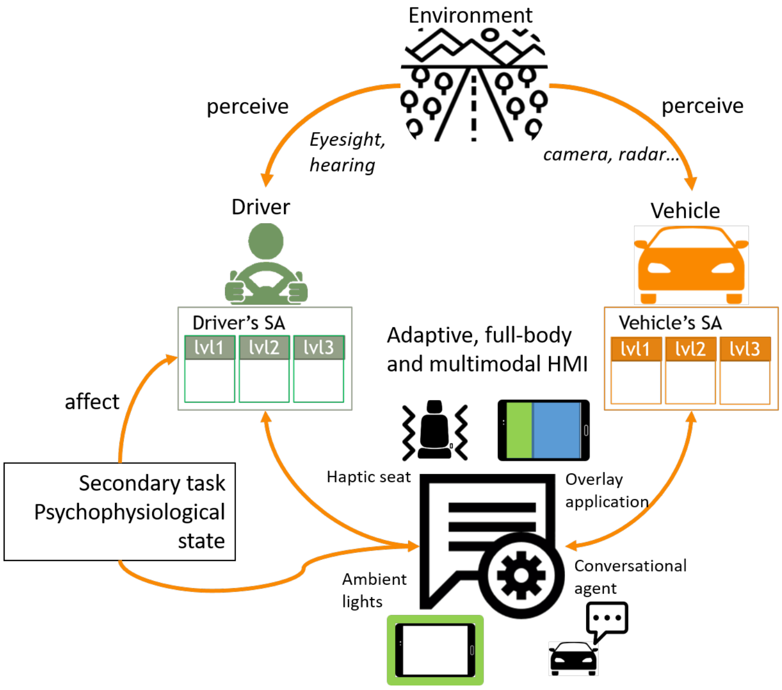

Figure 1: Multimodal and full-body interaction for supervision model

- **Overlay application:** Personal devices used by the driver while performing secondary task represents a novel and promising opportunity to communicate SA-related information to the driver in a peripheral way [8].
  Hypothesis: it may provide the driver with a more complete peripheral and extended vision and increase her/his trust to the automation [9].
- **Conversational agent and ambient lights:** Because ambient lights are often used to transmit information into peripheral vision of the user, it should represent a promising visual interaction to guide driver's attention [10]. Moreover, to make the user perceive the vehicle as a companion, it will be interesting to communicate with it like with any other passenger. The driver should be able to ask the vehicle about her/his surrounding environment conditions, car status...
  Hypothesis: it may develop transparency of the automation and increase driver's situation awareness and trust to the system.

Figure 2 shows pictures of the different concepts described above:

4. Tangible Interaction for Supervision in Level 3 cars

The introduction of tangible interactions within my project is currently under consideration. In the case of the haptic seat, it is a question of physically represent an extension of the vehicle environment through vibrations in the seat. Particularly, vibrations will map the proximity

Figure 2: Pictures of the concepts. From left to right: Haptic Seat, Ambient lights and conversational agent, Overlay application

sensors and sensors bound to the identification of lane markings into the driver's seat. The reasoning is quite similar regarding the use of ambient lights in the vehicle interior. Indeed, they should spatially represent the vehicle's environment by directing the driver's attention. The driver could then choose to obtain more information about this state by questioning the conversational agent. It might also be interesting to make the conversational agent more tangible by using a physical representation to begin with. This may comfort the driver when using the autonomous system and might increase the trust in the system. I would like to take advantage of this conference to discuss the tangibility of the proposed concepts. I also would like to get expert advice on how to use tangible interactions to increase driver's situation awareness and trust such as the project Carvatar [11] that uses a robot head placed on the car dashboard to inform the driver about the car's state and situation using social cues and anthropomorphism.

Acknowledgments

This work has been supported by Hasler Foundation in the framework of Ad-Vitam project. The authors would like to thank all the persons who contributed to this paper.

References

[1] S. International, Taxonomy and definitions for terms related to driving automation systems for on-road motor vehicles, 2018.

[2] E. Dogan, M.-C. Rahal, R. Deborne, P. Delhomme, A. Kemeny, J. Perrin, Transition of control in a partially automated vehicle: Effects of anticipation and non-driving-related task involvement, Transportation Research Part F: Traffic Psychology and Behaviour 46 (2017) 205–215. doi:10.1016/j.trf.2017.01.012.

[3] S. Bakker, E. van den Hoven, B. Eggen, Peripheral interaction: characteristics and considerations, Personal and Ubiquitous Computing 19 (2015) 239–254. doi:10.1007/s00779-014-0775-2.

[4] L. Cysneiros, M. Raffi, J. S. do Prado Leite, Software transparency as a key requirement for self-driving cars, in: 2018 IEEE 26th International Requirements Engineering Conference (RE), IEEE Computer Society, Los Alamitos, CA, USA, 2018, pp. 382–387. URL: https://doi.ieeecomputersociety.org/10.1109/RE.2018.00-21. doi:10.1109/RE.2018.00-21.

[5] T. Grah, F. Epp, M. Wuchse, A. Meschtscherjakov, F. Gabler, A. Steinmetz, M. Tscheligi, Dorsal haptic display: A shape-changing car seat for sensory augmentation of rear obstacles, in: Proceedings of the 7th International Conference on Automotive User Interfaces and Interactive Vehicular Applications, AutomotiveUI '15, Association for Computing Machinery, New York, NY, USA, 2015, p. 305–312. URL: https://doi.org/10.1145/2799250.2799281. doi:10.1145/2799250.2799281.

[6] A. Riener, A. Ferscha, P. Frech, M. Hackl, M. Kaltenberger, Subliminal vibro-tactile based notification of co₂ economy while driving, in: Proceedings of the 2nd International Conference on Automotive User Interfaces and Interactive Vehicular Applications, AutomotiveUI '10, Association for Computing Machinery, New York, NY, USA, 2010, p. 92–101. URL: https://doi.org/10.1145/1969773.1969790. doi:10.1145/1969773.1969790.

[7] M. Capallera, P. Barbé-Labarthe, L. Angelini, O. A. Khaled, E. Mugellini, Convey situation awareness in conditionally automated driving with a haptic seat, in: Proceedings of the 11th International Conference on Automotive User Interfaces and Interactive Vehicular Applications: Adjunct Proceedings, AutomotiveUI '19, Association for Computing Machinery, 2019, p. 161–165. URL: https://doi.org/10.1145/3349263.3351309. doi:10.1145/3349263.3351309.

[8] D. Miller, A. Sun, M. Johns, H. Ive, D. Sirkin, S. Aich, W. Ju, Distraction becomes engagement in automated driving, Proceedings of the Human Factors and Ergonomics Society Annual Meeting 59 (2015) 1676–1680. URL: https://doi.org/10.1177/1541931215591362. doi:10.1177/1541931215591362. arXiv:https://doi.org/10.1177/1541931215591362.

[9] M. Capallera, Q. Meteier, E. d. Salis, L. Angelini, S. Carrino, O. Abou Khaled, E. Mugellini, Tâche secondaire et conscience de l'environnement, une application mobile pour véhicule semi-autonome, in: Actes de la 31e conférence francophone sur l'Interaction Homme-Machine (IHM 2019), ACM, 2019, p. 12:1–10. URL: https://hal.archives-ouvertes.fr/hal-02381596. doi:10.1145/3366550.3372258.

[10] A. Löcken, W. Heuten, S. Boll, Autoambicar: Using ambient light to inform drivers about intentions of their automated cars, in: Adjunct Proceedings of the 8th International Conference on Automotive User Interfaces and Interactive Vehicular Applications, AutomotiveUI '16 Adjunct, Association for Computing Machinery, New York, NY, USA, 2016, p. 57–62. URL: https://doi.org/10.1145/3004323.3004329. doi:10.1145/3004323.3004329.

[11] J. Zihsler, P. Hock, M. Walch, K. Dzuba, D. Schwager, P. Szauer, E. Rukzio, Carvatar: Increasing trust in highly-automated driving through social cues, in: Adjunct Proceedings of the 8th International Conference on Automotive User Interfaces and Interactive Vehicular Applications, AutomotiveUI '16 Adjunct, Association for Computing Machinery, New York, NY, USA, 2016, p. 9–14. URL: https://doi.org/10.1145/3004323.3004354. doi:10.1145/3004323.3004354.