Rethinking transport
27–30 April 2020

TRA 2020 TRANSPORT RESEARCH ARENA HELSINKI

Proceedings of 8th Transport Research Arena TRA 2020, April 27-30, 2020, Helsinki, Finland

Enhancing Acceptance in Automated Vehicles through a new paradigm for colouring automated driving with human emotions

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Abstract

While the deployment of connected automated vehicle (CAV) turns into reality, its acceptance has been called into question. Societal issues regarding public acceptance, user awareness and ethics, therefore, become priority concerns. The approach based on the technology push, jeopardizes social viability of innovative technology like CAV, as it creates a gap between the well-thought technical reliability and public acceptance. The H2020 SUaaVE project (SUpporting acceptance of automated VEhicle) will solve this gap by leaning on a Human-Driven Design (HDD) approach, enhancing synergies social science, human factors research and automotive market by means of an iterative process of assessment, co-design and prototyping. Participatory process will involve above 4,000 users (passengers, traditional and future drivers, VRU) and 100 experts and stakeholders along the project. The paper will present an overview of the objectives and the methodology to be followed in SUaaVE.

Keywords: Connected and Automated Driving; Human-Driven Design; Cognitive and Emotional Model; Acceptance; Situational Awareness; Artificial Intelligence.

1. Introduction

The content of this paper covers a review about different concerns that affect the acceptance of CAV, followed by an overview of the H2020 SUaaVE project (SUpporting acceptance of automated VEhicle), which aims to enhance public acceptance of highly automated CAVs by increasing trustworthiness via Human-Driven Design. Methodology is described and finally conclusions are drawn.

2. Literature review

As the technology development for automated functions in vehicles progresses and the market introduction of connected automated vehicles (CAVs) approaches, deployment roadmaps start emphasizing societal issues related to CAV technology (ERTRAC, 2017). A recent report reveals that acceptance of CAV has a decreasing trend in USA as the society becomes more aware of the complexity of the technology (Andre & Letouzé, 2016). Indeed, a comprehensive report on Responsible Research and Innovation of the European Commission states that the chief reason for a contested technology to fail is because of societal needs and public acceptance are not taken into account in due time (Becker & Axhausen, 2017).

Public acceptance of CAVs is, therefore, of paramount importance, as it will determine whether the systems will actually be used (Cunningham & Regan, 2015). If connected automated driving is perceived as unacceptable, vehicle users may refuse to use it and negate all associated benefits (Ekman, Johansson, & Sochor, 2016). Additionally, as stated by ERTRAC in the Automated Driving Roadmap (ERTRAC, 2017), gradual deployment of CAV implies that conventional and automated vehicles will co-exist along with vulnerable road users (VRUs) for some time, making acceptance and harmonisation and a prime subject.

Going deeper, acceptance is a multi-faceted construct, chiefly related with trust, which covers from psychological factors to the characteristics of decision-making processes (Choi & Ji, 2015). In fact, trust in new technology is one of the key determinants of public acceptance and confidence and it influences adoption of new technology both directly and indirectly, via inducing affective response towards a new technology (ERTRAC, 2017). Therefore, in CAVs acceptance, one of the main obstacles is trusting the technology for potential users (European Commission, 2018). The lack of reliability and safety perception has been pointed out by most relevant studies as a key barrier for the adoption of technology that focussed on SAE-Level 4 and 5 (L4 and L5). Notably, based on the findings of a large-scale international survey (General Ministry of Transport and Digital Infrastructure, 2018), 54% of the respondents do not believe that CAV will function reliably, whereas another broad survey stated that the main reason for being unlikely to ride in automated vehicles for everyday use was lack of trust in the technology (Goswami & Dutta, 2015).

Furthermore, public will only accept CAV if they feel confident in placing trust not only in the safety and in the reliability of the technology, but also in its ethical standing and use. In this line, The European Group on Ethics in Science and New Technologies recommends that automated technologies should be aligned with fundamental values adhered by EU Treaties (ESI Group, 2018). Hence, ethical considerations linked to the protection of human life and integrity have to be tackled in the development and deployment of CAV. Addressing legitimate societal concerns on the ethics of CAV must have a central role in the process of guarantying public acceptance (Horberry, Stevens, & Regan, 2014).

Trust in automated systems can be increased by making the system more human-like (J.D. Power Cars, 2017), which will result the vehicle more predictable and usable for passengers and other road users in its surroundings. In fact, trust in CAV is based on feelings of safety and acceptance, making the emotional process one of the most influential aspects of confidence (Johansen, Fossen, & Berge, 2004). In a similar vein, CAV is likely to change the traditional notions and rules of user's relationship with the vehicle in space and time, for instance, by changing the traditional role of the driver in the vehicle. Passengers' comfort and wellbeing, usability with its components (such as satisfaction and effectiveness), will gain further importance in the case of CAV. Thus, recommendations for trustworthy and safe CAV, encompassing changing comfort rules and passengers' emotions in relation to CAV, are necessary.

3. Objectives and approach

SUaaVE is a project funded from the European Union's Horizon 2020 Research and Innovation Programme. The project aims to make a change in the current situation of public acceptance of CAV by leaning on a Human-Driven Design (HDD) approach, where the user is not only the centre of the process but actively contributes and even leads the definition of concept, development of technology and participates in its testing. SUaaVE focus on the human side, working to improve more "intangible" aspects as safety perception, attitudes and, in general, emotional appraisal of CAV.

SUaaVE involves all current and future users and other agents in a broad sense: passengers, current and future drivers (children, senior citizens and people with disabilities), VRUs (Vulnerable Road Users); and the main stakeholders leaning on a well-regarded and complementary Advisory Board (public authorities, industry, other sectors and user associations).

The SUaaVE outcomes that will enhance the acceptation of CAV are (Figure 1):

1. The new paradigm of automation: ALFRED -Automation Level Four^{+} Reliable Empathic Driver-. ALFRED is conceived as the fundamental architecture to understand the emotions of the passengers on-board of the CAV and to adapt the vehicle features to enhance the in vehicle user experience, while increasing acceptance. Compared to the CAVs developed under the traditional approach, ALFRED will contribute with the following two artificial intelligence units in the decision-making processes of the CAV:
    - "EMpathY" Unit (EmY), which will be in charge of understanding the emotional and cognitive state of the passenger, while taking into account ethical principles (Sensing and interpreting).
    - "Adaptive, Cognitive and Emotional" (ACE) Interface, formulated as the control strategies for the management of CAV behaviour to enhance trip user experience on-board (Acting and communicating). This will include the communication with the passenger via HMI and vehicular dynamic response.

    Both AI units will accurately cooperate, in Real-Time, to guarantee a satisfactory emotional state of the passenger during the trip, enhancing their acceptance.

2. Immersive Virtual Human Centred Design (V-HCD) platform, allowing the simulation of CAV focused on Human factors, assessing their acceptance through the involvement of future users.

3. Guidelines for support Public Authorities, representing a breakthrough in the public acceptance of future CAVs for both the society and, in particular, for all road users.

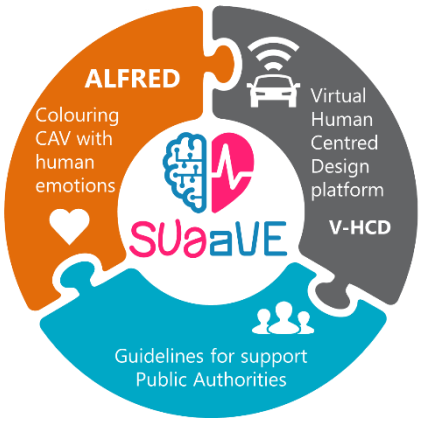

Fig. 1 SUaaVE approach. The path to acceptance.

SUaaVE will not only enhance the acceptance but will help European Industry to compensate three fundamental market risks: 1) the high number of tested miles of CAV in US versus the difficulties of testing CAV in EU, thanks to the simulation platform; 2) the new paradigm of automotive sector with new agents (Google, Tesla, Uber, etc.)

as well as new roles for TIER companies; and 3) the need to translate current "driving experience" to future "passenger experience", without losing the emotional link with the automotive customer. Furthermore, following the Human-Driven Design will allow to speed up and reduce cost of CAV tests, promoting a competitive advantage of European automotive manufacturers to keep and extend their leadership in transport industry all over the world. SUaaVE will contribute to generate new business models for the sector, ranging from exploiting personal data where the user is the owner and decide how to exploit it, to new services where the content is adapted to the specific state of the user in real time.

4. Methodology

SUaaVE project proposes to enhance public acceptance of highly automated CAV following Human-Driven Design (HDD), a methodology especially needed when designing for enabling and emerging information and communication technologies (Le Vine, Zolfaghari, & Polak, 2015). Following this approach, SUaaVE will develop synergies combining social science and human factors research, by means of an iterative process of assessment, co-design and prototyping. Participatory process will involve the European society by a survey in six European countries, with a participation of more than 3,900 citizens and, at least, 100 panellist. The iterative development process will involve the participation of around 500 volunteers in user tests, in five European countries, experiencing with ALFRED and its components.

5. Conclusion

SUaaVE will enhance public acceptance of highly automated CAVs by increasing trustworthiness via Human-Driven Design including the participation of all road users as well as stakeholders through the formulation of frameworks to enlarge public acceptance in the deployment of CAVs and by the formulation of ALFRED, defined as a concept to humanise the vehicle actions.

The result of the project will benefit different actors: (a) Society: boosting people's trust in CAV technology, (b) Industry: facilitating better integration of human factor in the deployment of CAV by tackling a Human-Driven Design, and (c) Public authorities: supporting decision makers with detailed recommendations, guiding them on how to align policy actions to absorb the substantial changes in mobility that will be caused by the rapidly emergence CAV technologies.

6. Acknowledgements

The paper presents the overall objective and the methodology of the project SUaaVE (SUpporting acceptance of automated VEhicle), funded from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement No 814999. The paper is based on the current view of the authors. With the development of the project, we will further develop and update the content presented here.

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