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An empirical investigation on consumers' intentions towards autonomous driving

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ABSTRACT

Major steps towards implementation of autonomous and connected transport are being taken nowadays. The trend of automation technology being used in vehicles by the most important vehicle manufacturing industries is expected to move closer to high or fully Autonomous Vehicles (AVs) through technological advancements in sectors of robotics and artificial intelligence. Vehicles with autonomous driving capabilities are planning to be available on market, in full scale, in the next years. In the longer term substantial benefits are mainly expected for accessibility to transport, safety, traffic flow, emissions, fuel use and comfort. All these potential societal benefits will not be achieved unless AVs are accepted and used by a critical mass of people. Addressing these challenges, this paper: (a) proposes a technology acceptance modelling process by extending the original Technology Acceptance Model (TAM) to explain and predict consumers' intensions towards AVs, (b) based on the proposed TAM-extended framework, a 30-question survey was conducted in order to investigate the factors influencing consumers' intensions to use and accept AVs. Results show that the constructs of perceived usefulness, perceived ease to use, perceived trust and social influence, are all useful predictors of behavioral intentions to have or use AVs, with perceived usefulness having the strongest impact. The insights derived from this study could significantly contribute to ongoing research related to technology acceptance of AVs and are expected to allow automobile industries to improve their design and technology.

1. Introduction

Recent developments in vehicle automation technology (e.g. automatic braking, automatic cruise control, intelligent speed assistance, line keeping assist systems, etc.) are moving us closer to increasingly autonomous and self-driving vehicles. This development complements the parallel development of connectivity in vehicles. According to their technological capabilities and human engagement, different levels of automation have been proposed. The most well-known are provided by SAE International (2016), where AVs can be classified in six categories ranging from Level 0, where the human driver does all the driving tasks and no automation is involved, to Level 5, where the autonomous driving technology system can perform all driving tasks, under all circumstances, and human occupants are just passengers and need never be involved in driving.

Based on the above the impact of AVs could be enormous. It could help to drastically reduce road fatalities as over 90% of road accidents come from human errors such as driving under distraction, speeding, alcohol, drug involvement and/or fatigue (Piao et al., 2016). Moreover, new transport services could also be developed especially when vehicles are provided with connectivity in addition

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to automation, e.g. traffic safety related warnings, traffic management, new possibilities for elderly people or impaired people, more individual comfort and convenience for drivers (Sparrow and Howard, 2017; Meyer et al., 2017). It could also result in new business models, such as car sharing services and shared mobility which could lead to a strong decrease of vehicles on our roads (Litman, 2018; Fagnant and Kockelman, 2015; Krueger et al., 2016).

All these potential societal benefits will not be achieved unless these vehicles are accepted and used by a critical mass of people; thus it will be important to understand consumers' acceptance before the arrival of AVs on international market. In this context it is not yet clear to what extent users accept automation technologies in vehicles and what the factors and determinants of user acceptance of automation are (Payre et al., 2014; Xu et al., 2018; Acheampong et al., 2018).

Furthermore, besides the numerous challenges with regard to vehicle automation and connectivity technologies, recent studies indicate that many key factors pertaining to the interaction between human drivers and full or partial autonomous driving systems are yet to be resolved. Such challenges include the impact of automated systems on drivers' workload and situation awareness, as well as the human drivers' levels of acceptance, trust and reliance on the automated systems (Milakis et al., 2017; Van Brummelen et al., 2018).

Moreover, challenges with regard to the required level of supervisory control and the role of the human drivers in the case of an emergency such as when automation fails or exceeds its functional limits (Kyriakidis et al., 2017) must be taken into account. Monitoring workload may negatively impact acceptance of AVs, as engagement with secondary tasks seems to be viewed as a primary end-user benefit of vehicle automation (Merat and Lee, 2012; Pettersson and Karlsson, 2015).

In recent years, various surveys have been conducted on public opinion and user acceptance towards the perception and adoption of automated driving systems on vehicles. These surveys show that the public has begun to embrace the portrayal of AVs in which the human driver has no supervisory control (Shin et al., 2015; Chowdhury and Ceder, 2016; Rahman et al., 2017; Daziano et al., 2017); thus more studies are required to fully explore the predictors influencing consumers' attitudes and willingness to use vehicles with autonomous driving capabilities. In this respect, the goal of this study is twofold: (a) to propose and validate a technology acceptance modelling process by extending the original TAM on user acceptance of AVs, and (b) based on the proposed TAM-extended framework to investigate in what extent consumers intend to use AVs in the future and what the main reasons for adapting or not adapting AVs are.

In order to fulfill these objectives, as this study focuses on partially or fully AVs to be realized in the future, the assessment was conducted among adults currently in their 18s to 70s who would be in their 30s to 80s by the year of 2030 when vehicles with autonomous driving technology are expected to be mature enough to be utilized in transportation activities. This is an important argument in light of the fact that partially or fully AVs have not been commercialized yet and the vast majority of consumers are rather unfamiliar with these emerging technologies.

The rest of the paper is structured as follows: Section 2 describes related research work on public opinion and user acceptance of AVs, whereas Section 3 presents the proposed research framework, the hypotheses, the research methodology and the profile of the participants. Details of the survey results on general attributes, factors associated with intent to use AVs and data analysis with hypotheses testing are reported in Section 4. The most important implications of the present study are discussed in Section 5, and concluding remarks and outlooks for future work are drawn in Section 6.

2. Related work

Research on technology acceptance, adoption and use of automation technology in vehicles has gained much value in transportation research. Silberg et al. (2013) conducted a survey targeting focus groups in California, New Jersey and Illinois of U.S.A. and asking their opinion on autonomous vehicles. It was found that the respondents were more interested in adopting autonomous vehicles when they were provided incentives like having designated lanes for autonomous vehicles. Additionally, people older than 60 years old and people between 18 and 25 years old stated the highest willingness-to-pay. Furthermore, Begg (2014) developed a survey about the likelihood of autonomous vehicles adoption targeting transportation experts in United Kingdom (UK) to ascertain their perception on whether and how soon the respondents would expect autonomous vehicles to become a reality. In this survey, 28% of the respondents stated that vehicles with Level 3 autonomous driving technology would be on UK public roads by 2040, and almost 25% stated that road transportation safety would improve with the implementation of autonomous vehicles.

Schoettle and Sivak (2014) investigated public opinion about autonomous and self-driving vehicles among 1533 respondents in the United States of America, the United Kingdom and Australia. The study showed that most respondents were interested in having completely self-driving vehicle technology, but the majority of respondents said they would not be willing to pay extra for this technology. U.S. respondents expressed greater concern than those from the United Kingdom or Australia regarding data privacy, interaction with non-self-driving vehicles, learning to use the vehicles and vehicle performance in poor weather conditions. Moreover, Underwood (2014) investigated the opinion of 217 transportation experts on automated vehicles. Respondents considered legal liability and regulations as the most difficult barriers toward the deployment of fully automated driving vehicles, whereas social and consumer acceptance were regarded as the least difficult barriers.

Kyriakidis et al. (2015) carried out a survey on public opinion about automated driving among 4886 respondents in 109 countries. In this study respondents indicated that fully automated driving (Level 5) would be easier than manual, whereas partially automated driving (Level 3) was perceived as more difficult. Concerns focused on software hacking and misuse, legal issues, and safety. Also, 20% of the respondents stated that they would be willing to pay $7000 more for a Level 5 fully autonomous vehicle and almost 70% stated that autonomous vehicles could gain around 50% market share by 2050. On a similar note, Payre et al. (2014) investigated 421 driver's attitudes in France in 2014 and a priori accessibility of autonomous vehicles, as well as their intention to use an autonomous