Adaptive of Autonomous vehicles: Review on differentiating behavior of Human-driven vehicles and Autonomous vehicles

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Abstract. In this review, we will take a look at the currently available automated driving system (ADS) which has potential benefits to traffic flow, fuel consumption, and safety, but we will see how the human driving vehicles (HDV) and human behavior whilst driving with ADS is poorly understood with differentiated factors reviewed in this paper with autonomous vehicles (AV). Collective evidence showing the coexistence of human-driven vehicles and autonomous vehicles creating a mixed intelligent traffic network. A phenomenon that proves AVs lane changing with surrounding HDVs maneuvers more comfortably and safer. Finally, a glimpse into critical human factors and ethical considerations in the domain of AVs integration with artificial intelligence. [7]

Keywords: Human-driven vehicles · Autonomous vehicles · human factors · adaptive system

1 Introduction

The level of automation of an intelligent system present in a vehicle can vary from a human-driven vehicle to a completely autonomous, or self-driving vehicle. A classification system was published by SAE International (Society of Automotive Engineers), in 2014, which defines 6 different states of levels where a vehicle's automation is given taking into account the amount of driver's attentiveness and intervention required, rather than the capabilities of a vehicle, although these are closely related. The standard six levels defined level 0 to level 3 which have been developed and adapted by various automotive manufacturers in some of their autonomous vehicles to date. Later in this paper, we will take a look at the future development which are considered to be level 4 (high automation) and level 5 (fully autonomous). Although, in recent years, with advancement in technology and in-depth development and consumer behavior in the adaptation of the level 3 autonomous vehicles has provided a lot of insights to the automotive industry on developing the technology and predicting the consumer's behavior and their needs by collecting eccentric data and usage behavior. [1, 10]

This paper will provide a deep dive into a definitive future of the coexistence of both types of vehicles, field experiments on the behavior of human-driven vehicles (HDVs) and autonomous vehicles (AVs) with differentiating perspectives and methodologies in adapting. A brief overview of critical human factors, and ethical considerations in advancing autonomous vehicles. Finally, concluding the paper with key takeaway points.

2 Literature

2.1 Longitudinal Characteristics of a human driver behavior following an autonomous vehicle

According to Zhao et al, To understand the fundamental choice between a human-driven vehicle or an autonomous vehicle, authors in this research study provide the evidence and bridge the gap between understanding the longitudinal characteristics involving both types of the vehicle where field experiment was conducted to reveal differences in car-following behaviors, between a human-driver vehicle, following an autonomous vehicle and following HDV conditions such that both are at constant speed traffic characteristics with constant speed (10,20,...,60)km/h and dynamic car-following behaviors with continuous speeds (in range of 0-60)km/h in both undifferentiated and differentiate appearance settings of the autonomous vehicle. The authors recruited 10 drivers for the experiment; on testing the data collected such as positions and speed of the vehicles along with their complete trajectories based on gaps between vehicles, headways, and standard deviations of vehicle speed. Machine Learning algorithm used to classify drivers based on their responses in the following autonomous vehicle vs that of following a human-driven vehicle as the constant parameter being speed and dynamic speed characteristics. [9, 12]

The factor that is most brought upon after the testing and field experiments is trust in AV technologies, where the findings were aligned as drivers who trust the most in AV technologies tend to keep a smaller gap between their vehicles when following AV.

1. They (test drivers) said that they knew AVs have better and more precise vehicle control, further sensing distance, and faster computation.
2. AVs are also capable of handling potential risks and chances to avoid those are greater such as the use of extreme brakes, thus following AV more closely can reduce the travel time and avoid other vehicles cutting in which can avoid collisions and traffic congestion.
3. On the contrary with the first, drivers who have doubts about autonomous technologies usually have a greater gap from the lead AV, and from the second point, drivers believe that these AV technologies are still in development and being tested and the possibility of having some abnormal behaviors at any moment.

2.2 Predicting necessity of traffic system with mixed autonomous vehicles and human-driven vehicles

Furthermore, details on mixed autonomous vehicles and human-driven vehicles for the future intelligent traffic system proposed in the paper by Chen et al. The co-existence of both vehicles at some point is possible in a complex traffic system from a micro perspective which is based on the cellular adaptive automation model, by the use of sensors or mutual information exchange between each AV will have a such a deep insight into the parameters of a subsequent AV such as speed and future trajectory of the vehicles in front of it. Which can certainly have an impact on the traffic systems, whereas on the other hand after studying a circular road scenario, how the traffic capacity is influenced by the foresight of a vehicle, the findings for the ratio of AVs to HVs, density of the vehicle, and the most contributing factor was the probability of randomness in deceleration in HVs. One of the critical impacts of this scenario is that vehicles can cause traffic systems in a deadlock state and vehicles are not able to move resulting in frequent traffic congestion.

This study presents us with the knowledge of how there will be an intersection of such mixed scenarios of vehicles and how the adaptive mechanism will be crucial to navigate without negative loss. The gathered results are valuable which states the information for every manufactured AVs to have is the data 5 vehicle's in front of it to achieve the traffic network optimization. Along with the vehicle's density and maximum average speed or flow which measures the capacity and efficiency, increase with the increasing adaption of AVs to that of HDVs. The increasing probability of random deceleration can reduce the average flow which implies a greater amount of AVs on the roads that can control and reduce any negative impact that might be caused by these mixed-traffic systems. [6]

2.3 Experiments on autonomous vehicles lane changing adaptive system with surrounding human-driven vehicles

This paper reviews another fundamental aspect was explored by Wang et al. that can differentiate the technological advancement of an autonomous vehicle from human-driven vehicles which experiments on a critical link that has a decision-making behavior model to compute to be a higher level AV which is lane changing by considering the following parameters which include the dynamics of surrounding vehicles (including HDVs), particularly in a mixed traffic environment. Findings from these experiments result in that the model proposed of lane-changing navigate efficiently when HDVs are cooperative and can also vigorously abort them when HDVs are uncooperative. The model proposed had the following four components to evaluate such as car-following (and lane-keeping) (this parameter is similar to review-1), the decision on lane-changing, dynamic trajectory generations, and model predictive control - based on trajectory tracking along with different human driver behaviors are also been considered in this experiment settings. Comparing the results to human lane-changing navigation, Wang et al prove that AVs lane-changing navigation from the above-proposed model are more comfortable and safer.

The study of this paper was to address research gaps in the field where the increasing technology from a version to version and in an increasing adaption rate by people these AVs will be in a mixed environment, particularly exploring into the dynamics of these surrounding vehicles. Hence, a model such as this was proposed where we took a look at the key components between AVs and HDVs coexisting in a mixed environment until all the vehicles are AVs. AVs lane-changing model helps us navigate much smoother and safer than the HDVs. [3, 11]

3 Critical Human Factors

In the context of the current level, 3 of the autonomous model was developed that identifies critical human factors that introduce human errors and consequently causing accidents by lack of interactions between HDVs and AVs adapter have not been examined thoroughly because user acceptance and trust are substantial for further sustainable developments of AVs, there are several factors to consider which were proposed by Cárdenas et al.'s their findings being complex in identifying critical human factors which influences a take-over performance. Age, focus capabilities, multitasking capabilities, IQ, and learning speed are mostly related to cognitive human factors in autonomous vehicle driving.

By considering these factors in designing a seamless understanding and interaction between drivers and automating driving system will enhance user experience as well as acceptance of the technology to move forward in a more sustainable environment in large-scale adaptability. [4]

4 Ethical considerations

Poszler et al. bring to light the most important ethical considerations and findings from the researched paper we can identify following identification of key issues that can be taken into account are Technical Safety involves defining 'safe' fallback plans, potential cyber securities threats on the online systems of autonomous vehicles. Responsibility of balancing risks that are deciding implicitly who is exposed to greater risks, rather than making a decision between the protection of driver/ owner and outright sacrificing others, where the factors about risk allocation and decision-making process can be questioned.

Accountability, responsibility, and liability question in what way the change of laws and regulations as autonomous vehicles advanced and adaption is widely scaled, the responsibility is in question in case of an accident that involves an autonomous vehicle. However, the exchanging of vast amounts of data becomes evident that it is necessary to bypass inefficiencies but this may come at cost of extracting and using more users' data (such as vehicle locations). AI and AVs are used as a summation to uplift technology even more thus bringing us to some of these trade offs which AVs try to meet some of the principles regarding technical safety, responsible balancing of risks, and accountability. In the future, leading automotive manufacturers and AI developers, and policymakers will need to develop an agreement on compromises and prioritization among these ethical considerations, as well as providing relevant solutions. [2]

5 Personalized AVs and approach to cognitive behavior

The idea to explore personalization of AVs is the trustworthiness of user or driver to achieve that an approach was proposed and examined to gain a higher level of acceptance, as we discussed from review the fundamental basis that user has with AVs comes to how much a user trusts AVs technology. From the paper Sun, et al. successfully provide evidence that personalized AVs could enhance the performance of ADS. Stating as these personalized AVs will be effective and efficient to drivers' preferences and behaviors in adapting dynamically the automation performance according to each driver and will be resilient to various driving styles. Though, the study has few limitations such as driver behavior will be exactly similar while in a simulator to that in the real world. Second, there is not much knowledge about the long-term effects of drivers' levels of trust with an AV and behavioral adaption over time. [5]

Cheung et al. describe the possibility to classify driver behaviors for AVs navigation and how those behaviors can be used as safer navigation of AVs by computing vehicle trajectories with a data-driven mapping method between features and derived different criteria of the driver behaviors with a summarized score indicating awareness level needed while driving next to other vehicles which are aggressive or dangerous. The study presents six driving behavior metrics stated such as aggressive, reckless, threatening, careful, cautious, and timid. Along with attention metrics such as when - following, preceding, driving next to, and far from the target. [8]

6 Conclusions

This paper states clear findings on differentiating factors and perspective by reviewing three different perspectives conjugating on human-driven vehicles and autonomous vehicles; authors of the three reviewed papers experiments and present the findings for one of the most complex adaptive systems to be integrated as we advanced and iterate our approach in adapting, building trust and developing models through user interactions.

As we move on from level 3 autonomous vehicles to level 4 and level 5 in a near future, we can utilize these adaptation techniques which are proposed in how user acceptance rate is dependent, how we need to develop an intelligent traffic system so that when we will face a greater amount of human-driven vehicles and autonomous vehicles at the same time, and finally how AVs can navigate with surrounding HDVs by the approach of the lane-changing model suggested which also includes a more advanced AI learning models to integrate with AVs and with that the study reviewed consideration of ethics.

A discussion on the most measured critical human factors while driving autonomous vehicles suggested age, focus, multitasking, IQ, and learning speed explains the majority of take-over errors related to the cognitive behavior of drivers. The more AVs progress, we can develop a model proposing user personalized AVs and cognitive approach to well adapt as per the users' behavior such as driving style and characteristics and a designed that is socially acceptable and trustworthy.

Moving towards the future the projection such as to level 4 and level 5 the perception of AVs can be mapped from the paper proposed by Brummelen et al. [13] that perception systems present can be improved so much before becoming fully autonomous which discussed required improvement on reduction of uncertainty as well as reduction in costs of perception systems, and operating safety for algorithms and sensors, while putting forth a future scope on the efficiency of computational methods and such algorithms for AV perception, then AVs will be more likely be driving on public roads with enhance technology such as improved reliability and accuracy GPS in real-time and advancing in communication between V2V and V2I to reduce localization uncertainty which will increase driving safety, mobility, and sustainability in the near future.

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Acronyms

ADS : Automated Driving System
AI : Artificial Intelligence
AV : Autonomous Vehicles
HDV : Human-driven vehicles
IQ : Intelligence Quotient
SAE : Society of Automotive Engineering