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Vehicles, Advanced Features, Driver Behavior, and Safety: A Systematic Review of the Literature

Raghuveer Prasad Gouribhatla, Srinivas Subrahmanyam Pulugurtha

IDEAS Center, Civil & Environmental Engineering Department, The University of North Carolina at Charlotte, Charlotte, USA
Email: rgouribh@uncc.edu, sspulugurtha@uncc.edu

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Abstract

Driver errors contribute to more than 94% of traffic crashes. Automotive companies are striving to enhance their vehicles to eliminate driver errors and reduce the number of crashes. Various advanced features like lane departure warning (LDW), blind spot warning (BSW), over speed warning (OSW), forward collision warning (FCW), lane keep assist (LKA), adaptive cruise control (ACC), cooperative ACC (CACC), and automated emergency braking (AEB) are designed to assist with, or in some cases take over, certain driving maneuvers. They can be broadly categorized into advanced driver assistance system (ADAS) and automated features. Each of these advanced features focuses on addressing a particular task of driving, thereby, aiding the driver, influencing their behavior, and enhancing safety. Many vehicles with these advanced features are penetrating into the market, yet the total reported number of crashes has increased in recent years. This paper presents a systematic review of these advanced features on driver behavior and safety. The review is categorized into 1) survey and mathematical methods to assess driver behavior, 2) field test methods to assess driver behavior, 3) microsimulation methods to assess driver behavior, 4) driving simulator methods to assess driver behavior, and 5) driver understanding and the effectiveness of advanced features. It is followed by conclusions, knowledge gaps, and need for further research.

Keywords

Vehicle, Advanced Driver Assistance System, Automated, Driver, Behavior, Safety

1. Introduction

Traffic deaths are a major issue worldwide. They are the leading cause of deaths among people up to 54 years in age in the United States [1]. Newer vehicles are added to the roads with every passing year further aggravating the traffic congestion and safety problem. As an example, more than 17.6 million passenger cars and trucks were sold in 2016 alone while more than 3.21 trillion vehicle miles traveled were estimated in 2018 [2] [3].

It is estimated that 94% of traffic crashes occur due to driver error [4]. These errors are broadly classified into recognition errors, decision errors, performance errors, and non-performance errors, and contribute to 41%, 34%, 10%, and 7% of the crashes, respectively [5]. In general, non-performance errors are random in nature and account for a relatively small percentage of driver errors but difficult to address.

As driver errors are the major contributor of traffic crashes, a continuous effort is being made by automotive companies and researchers to manufacture vehicles with advanced features and reduce human intervention in driving, influence driver behavior as well as enhance safety, with the ultimate goal of complete automation in the future. **Figure 1** shows a schematic of example advanced features.

The external advanced features are driven by sensors with varying detection ranges. The adaptive cruise control (ACC) has the longest detection range and uses long range radar systems while emergency braking and collision avoidance systems use light detection and ranging (LiDAR). The warning or alerting systems like blind spot warning (BSW) use sensors that have smaller detection ranges

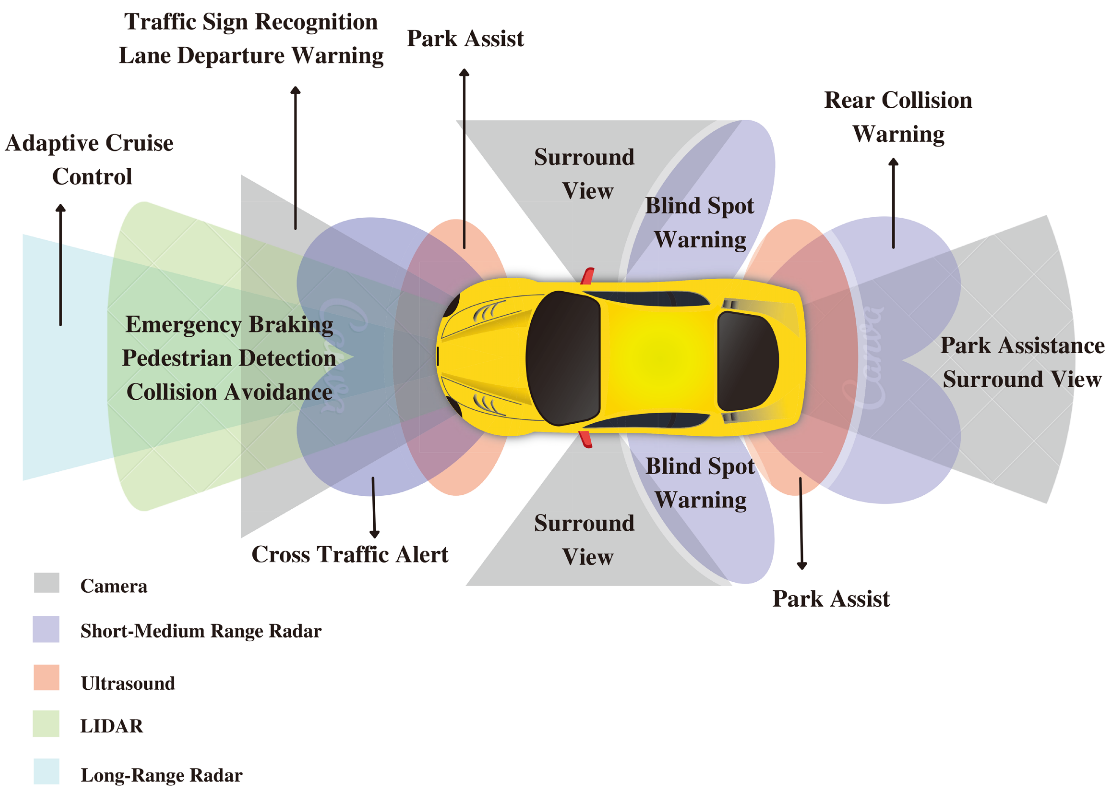

Figure 1. Advanced features in a vehicle.

while partially automated systems use sensors with longer detection ranges. These systems also deliver progressive levels of assistance based on the user needs, as classified by Safelite Auto Glass [6].

The advanced features can be broadly categorized into advanced driver assistance system (ADAS) and automated features. BSW, lane departure warning (LDW), over speed warning (OSW), and forward collision warning (FCW) are example ADAS features. Likewise, ACC, cooperative ACC (CACC), lane keep assist (LKA), and automated emergency braking (AEB) are example automated features. ACC and LKA (also referred to as active lane keeping) are automated features seen in many Level 1 and Level 2 connected and automated vehicles. ACC is an automated system that maintains a designated speed and following distance from the leading vehicle. This system can adjust its speed based on the leading vehicle and can also make a complete stop if required. LKA is another automated feature that ensures the vehicle stays in its lane by steering control of the vehicle.

The penetration of vehicles with advanced features like ACC and CACC can aid in better traffic flow performance, improve traffic stability, and influence road capacity [7]-[14]. However, the effectiveness depends on the percent of vehicles with such advanced features in the traffic stream [8] [13].

Agencies like the National Highway Traffic Safety Administration (NHTSA) and the Federal Highway Administration (FHWA) have been, therefore, investing efforts to constantly monitor the performance of various emerging advanced features and to evaluate their acceptance and ease of use via testing procedures as well as penetration into the market in the United States [15]. Further, the NHTSA [16] publishes articles and publicizes the advantages of ADAS, while explaining their working mechanisms and limitations to help educate drivers.

Reviewing and investigating past research efforts invested into addressing issues related with ADAS and automated features is vital to understand their effects on driver behavior and safety. Also, at the same time, this exercise helps in identifying methodologies adopted by past researchers and any prevailing knowledge gaps, which serve as a guiding platform to establish a more concrete framework going forward. An extensive synthesis of past literature was, therefore, carried out. The remainder of this manuscript presents an overview of the past research efforts categorized into 1) survey and mathematical methods to assess driver behavior, 2) field test methods to assess driver behavior, 3) microsimulation methods to assess driver behavior, 4) driving simulator methods to assess driver behavior, and 5) driver understanding and the effectiveness of advanced features.

2. Survey and Mathematical Methods to Assess Driver Behavior

Abdul *et al.* [17] investigated driver behavior based on the pressure applied on brake and gas pedals. They employed a cerebellum model articulation controller

(CMAC) to model driver behavior. They observed the application of CMAC to be reasonable for predicting various driver behavior characteristics and understand the effects of a drivers' emotion and his/her subconscious mind. Wang *et al.* [18] evaluated driver behavior based on the acceleration and brake force parameters and steering wheel angle using mathematical models. They used these parameters to incorporate into ADAS and observed that driver behavior varies for different driving actions and generalizing driver behavior based on only a few actions is not ideal. Similarly, Kamaruddin and Wahab [19] tried predicting driver behavior based on speech configuration. They evaluated driver behavior based on the emotion conveyed in their speech patterns and observed that it can be used to profile driver behavior, especially when they are sleepy.

Kuge *et al.* [20] evaluated driver behavior using hidden Markov model (HMM). They demonstrated the efficient application of HMM in both application and in modeling driver behavior, particularly for lane change behaviors. Sathyanarayana *et al.* [21] also developed an HMM framework to identify driver behaviors and distractions using mathematical models. Tran *et al.* [22] used vision-based foot gestures and HMM to analyze and predict braking behaviors of drivers. While they used visual methods to capture driver behavior data, they employed HMM to predict the pedal pressing gestures, and achieved a 94% accuracy by this method.

Yannis *et al.* [23] investigated the acceptance of ADAS among older driver via surveys from 23 European countries. Their results showed relatively better acceptance of ADAS among older drivers and females. Morignot *et al.* [24] evaluated the effectiveness of and acceptance of ADAS via a surveying method and made recommendations for improving the technology in the future. Findings from the past also indicate that the ratings of trust in ADAS technologies increased with the length of vehicle ownership while unexpected system behavior decreased participants ratings of trust over time [25].

3. Field Test Methods to Assess Driver Behavior

Alkim *et al.* [26] investigated the effects of LDW and ACC on driver behavior using a field vehicle in Netherlands. They observed an 8% improvement in traffic safety and a 3% reduction in fuel consumption. Additionally, they estimated a 10% reduction in emissions.

McCall *et al.* [27] focused on developing human-centric ADAS, such as predictive braking and ACC, and their effects on driver behavior using a test vehicle in real-world driving conditions. Cognition-based adjustments were made to the vehicle to capture driver behavior and the framework showed promising results. Ziefle *et al.* [28] evaluated the effects of visual and auditory ADAS on older drivers. They observed better driving performance in the absence of any ADAS, while auditory systems contributed the highest to distraction. Their findings indicate that older drivers preferred auditory systems over visual systems.

Inata *et al.* [29] modeled driver behavior using micro-electric sensors mounted on vehicles which were driven in real-world traffic environments. The sensing equipment recorded the pedal operation of the vehicle, which was used for analyses. They developed a theoretical model to estimate driver behavior and then compared it to the collected urban driving data to distinguish hurried driving from relaxed driving. Angkititrakul *et al.* [30] used mathematical models (Gaussian mixture model) and algorithms (piecewise auto regressive exogenous) to understand driver behavior and incorporate them into car-following models. The data used was obtained from real-world driving conditions. They captured braking and acceleration parameters in response to the distance from leading vehicle. The framework was then used to evaluate and model driver behavior.

Kondyli and Elefteriadou [31] investigated driver behavior using data obtained from driver responses to various questions that addressed their thinking while merging from a ramp onto a highway. They tried to correlate the driver's behavioral thinking to driver characteristics. Pauwelussen and Feenstra [32] investigated the effects of LDW and ACC on driver behavior in real-world driving conditions. They observed that ACC feature led to larger headways between vehicles while manual override of the system resulted in shorter headways.

Farah and Koutsopoulos [33] probed into the effect of infrastructure to vehicle (I2V) assistance systems on drivers using test vehicles. They observed reduced ranges of acceleration and deceleration while the car-following was more synchronized. Olaverri-Monreal *et al.* [34] probed into the effect of the location and angle of in-vehicle displays on driver safety. They observed the driver gaze when looking at driver information systems in the vehicle that are currently existing in the market, and inferred that they meet the NHTSA guidelines for the gazing away from road values. The driver preferences with the in-vehicle display and location converged with that in the market, while mobile applications and social media were not found to be necessary in the vehicle.

Son *et al.* [35] employed a road-testing method to evaluate the acceptance of FCW and LDW based on the age and gender of the driver. While females and younger drivers showed lowest acceptance of ADAS features, males and middle-aged drivers showed higher likelihood of acceptance. Miyajima *et al.* [36] developed machine learning models to analyze data collected from real-world driving conditions over 15 years. They observed various driver behaviors including lane changes, car-following, and pedal operation. They developed statistical models to predict risky driving and frustrated driving behaviors. Sieber *et al.* [37] investigated driver behaviors in collision avoidance using a field test study. They observed driver behavior and perception with different times of collision, and observed that the movement speed of the obstacle had the greatest effect on driver behavior.

Cades *et al.* [38] investigated the effects of LDW on driver behavior while the participants performed a secondary task. They observed no significant effect of LDW in reducing driver workload and driver cognition while performing secondary tasks. Lyu *et al.* [39] investigated the effect of ADAS on driver behavior using field operational tests in China on a test route. The effects of FCW and LDW were primarily assessed in their study. They observed increased braking time and decreased relative speed when provided with ADAS. Also, higher acceptance of FCW was observed over LDW. The acceptance was higher on freeways compared to urban roads.

4. Microsimulation Methods to Assess Driver Behavior

Kikuchi *et al.* [40] probed into the effect of using ACC in platooning, based on the different positions of the vehicle, using microsimulation. They observed reduced reactions times to achieve stability in the platoon. Both, ACC equipped and non-ACC equipped vehicles were observed to display enhanced safety. Derbel *et al.* [41] investigated the effect of mixed traffic, comprising of vehicles equipped with ACC, in a crash scenario. Enhanced safety and reduced crash risk were observed when vehicles equipped with ACC were involved in a crash.

Jeong *et al.* [42] investigated the effect of an inter-vehicle safety warning information system (ISWS), which communicates hazardous maneuvers of vehicles that could lead to a crash. The driver behaviors captured using probe vehicles were fed into VISSIM simulation, while the Surrogate Safety Assessment Model (SSAM) was used to assess safety. Rear-end conflicts were observed to reduce with penetration rates, while congestion increased. The standard deviation of speed was observed to decrease by 40%.

Researching the effectiveness of multiple integrated systems, Li *et al.* [43] evaluated the effect of integrating I2V with ACC and variable speed limit (VSL) in different combinations on traffic safety. The time exposed time to collision (TET) which indicates the total time spent by a vehicle in safety-critical situation and time integrated time to collision (TIT) which is time remaining for a collision to occur if two vehicles continue to maintain the same speed were used as surrogate safety measures in their study. The effect of integrating technologies established better results when compared to individual effects. Employing a similar methodology, Li *et al.* [44] evaluated the effects of ACC on safety of freeways. Enhanced safety was observed with the increase in penetration rates, while the combination of ACC and VSL were observed to produce the best results. Li *et al.* [45] also investigated the effect of CACC on rear-end crash risk on freeways. A significant reduction in crash risk was observed with CACC while the TET and TIT reduced by over 90%.

Li *et al.* [46] designed simulation experiments to evaluate safety effects of advanced features like FCW, AEB, ACC, and CACC. Their findings indicate that FCW and ACC perform poorly in reducing multi-vehicle rear-end crashes while the AEB performs better due to automatic perception and reaction as well as the full brake if needed during small-scale inclement weather conditions. The CACC has the best performance as wireless communication provides a larger sight distance and a shorter time delay.

Likewise, Cicchino [47] analyzed the effectiveness of FCW, AEB, and a combination of both in reducing rear-end crashes. FCW, AEB, and combination of both reduced rear-end crashes by 27%, 43%, and 50%, respectively. The vehicles themselves being struck in rear-end crashes reduced in case of vehicles with individual systems but increased when the vehicles were equipped with both the systems. In an attempt to investigate the effects of integrating connected vehicle technology with other systems, Yue *et al.* [48] probed into integrating connected vehicles with different ADAS. About a 70% reduction in crashes was achieved with the integration, while FCW reduced rear-end crash risk by 35% in foggy conditions.

5. Driving Simulator Methods to Assess Driver Behavior

Kaptein *et al.* [49] revealed that driving simulator-based study results are valid, and that the validity increases with the resolution of the simulation and the presence of a moving base. Strayer and Johnston [50] investigated the effect of conversing on cellular phones on driving, using a driving simulator. They observed longer reaction times to traffic lights while conversing, irrespective of hand-held or hands-free devices. Similarly, in another driving simulator-based study by Strayer *et al.* [51], using hands free devices for conversation was observed to increase reaction times when stopping at intersections, due to reduced visual attention.

Choudhary and Velaga [52] investigated the effects of talking and texting on a phone on driving behavior in a suddenly arising situation (pedestrian crossing) using a driving simulator. The mean speeds were observed to reduce if the drivers were on phone, while the probability of a crash increased by 3 to 4 times. Strayer and Drews [53] observed that the effect of cell phone conversations was higher on young drivers compared to older drivers. In another study, Strayer *et al.* [54] observed that the drivers were involved in a comparatively higher number of crashes when talking on cell phones owing to decreased reaction times to braking, while intoxicated driving led to smaller headways from leading vehicles. Overall, the effect of conversing and intoxication were observed to have similar effects when the driving conditions and time to task were the same in their study. Further, text messaging was also observed to constrain driver attention to braking lights significantly leading to crashes [55].

Lundgren and Tapani [56] investigated the safety effects of ADAS using a driving simulator. They observed that the functionalities of ADAS and changes in driver behavior for ADAS equipped vehicles could affect safety. Driver-vehicle behavior was observed to substantially affect safety. van Driel *et al.* [57] evaluated the effectiveness and acceptance of congestion assistant using a driving simulator. They observed improved driver safety behaviors when approaching a traffic jam. Lee and Abdel-Aty [58] captured driver responses to warning messages and VSL using a driving simulator. They observed that the variation in driving speeds reduced, leading to better traffic flow and reduced congestion.

Hoogendoorn and Minderhoud [59] investigated the effects of intelligent cruise control and intelligent speed adaptation on driver behavior. They observed improved capacities and reduced reliability at bottlenecks when cruise control was deployed, while no improvement in either capacity or reliability was observed in the case of intelligent speed adaptation. No improvement in safety was observed. Martin and Elefteriadou [60] researched the effect of ADAS on driver behavior using a driving simulator. They observed changes in driver behavior when using vehicles equipped with ACC and lane change on arterials/ freeways. Calvi and Blasis [61] evaluated the effect of driver behavior in acceleration lanes. They observed that driver merging behavior was dictated by the traffic volume on main roads and the acceleration lane length had no effect on their merging behavior.

Son *et al.* [62] assessed the effect of voice recognition system on driver distraction, especially for older drivers. The distraction effects were evaluated for both urban and highway sections, and it was observed that both age and environmental conditions effected driving behavior when the driver had to perform two tasks. Mas *et al.* [63] investigated the effect of lateral control assistance systems on driver behavior in avoiding obstacles using a driving simulator. They observed an equal effect from both assisted and non-assisted drivers in avoiding obstacles. However, the lateral control assistance system contributed to faster reaction times.

Maag *et al.* [64] investigated the effects of ADAS on drivers, using single and multi-driving simulators. They evaluated the effects of advanced features and supported the use of multi-driving simulators in understanding and capturing driver behavior. Saleh *et al.* [65] probed into the compatibility of driver and LKA using a driving simulator. They observed better lane keeping when the system was engaged, despite varied driver behavior. Aziz *et al.* [66] investigated the understanding of LDW and its effect on driver behavior using a driving simulator. They observed that the dynamic nature of the driving environment could itself limit the driving cognitive model leading to cautious driving scenarios that could result in a tragedy, irrespective of any secondary tasks performed by the drivers.

Rommerkirchen *et al.* [67] investigated human-machine interactions to understand the effect of ADAS on drivers using a driving simulator. They observed that the game-time (interaction) reduced in complex driving situations. In a similar study, Biondi *et al.* [68] investigated the effect of a beeping ADAS on driver behavior using a driving simulator. They observed that the beeping sounds disrupted the vehicle trajectory as the drivers deviated from the lane. They observed such sounds to be distracting for the driver in contrast to their original functionality.

Spivey and Pulugurtha [69], using a low fidelity driving simulator, evaluated the visibility of two-wheelers encountered by left-turning motorists at urban intersections under nighttime conditions and compared them with other hazards. The observed response times to a two-wheeler were not different from the response times to a passenger car with two headlights. However, the response times were significantly shorter than the times to recognize no hazard or a two-wheeler with no headlight. Differences were observed when response times were compared for daytime and nighttime conditions.

Gaspar *et al.* [70] evaluated driver behavior when provided with FCW and LDW using a driving simulator. They compared the effects on both distracted and undistracted drivers and observed that the driver behaviors fell into categories based on distraction. Significant variation in driver lane change behavior was also observed in their research. Witt *et al.* [71] investigated the effect of driver characteristic and personality on driver behavior using virtual and driving simulations. They attempted to develop driver cognitive model to help design ADAS. Phone use was observed to significantly effect safe driving for both younger and older drivers, with younger drivers having higher crash risk compared to experienced drivers in a driving simulator [72].

Gouribhatla and Pulugurtha [73] collected data for 129 scenarios and 43 participants to evaluate the influence of LDW, BSW, and OSW on the driver behavior. They observed that driver's responses are different in rural, urban, and freeway driving scenarios, and varied with their age, gender, ethnicity, lighting, and weather condition. Automated systems like ACC and LKA were observed to reduce the variation in driving behavior across different drivers compared to both warning systems and no ADAS conditions [74]. Safer vehicle handling, lane-following, and car-following behaviors were observed for drivers provided with automated systems compared to drivers provided with warning systems and drivers not provided with any ADAS.

6. Driver Understanding and the Effectiveness of Advanced Features

Extensive efforts have been and are being expended to improve operational performance and traffic safety by developing, testing, and implementing new ADAS and automated features. Despite these efforts, a 14% increase in road related deaths was recorded from 2014 to 2016 [75]. There have also been debates over advanced features making drivers more reluctant and distracted, resulting in unwanted side effects [75].

Eichelberger and McCartt [76], based on interviews of owners of 2010-2012 vehicles with ADAS and related features, observed that most respondents always leave the features on, although fewer do so for LDW (59%). The ACC seem to be aiding the drivers by following less closely while LDW seem to be aiding the drivers in using turn signals more often. About one third of the respondents experienced autonomous braking when they believed they were at risk of crashing while about one fifth of the respondents thought it had prevented a crash. However, about one fifth of the respondents were confused or misunderstood which safety system had activated in their vehicle.

In a relatively recent study, McDonald *et al.* [77] revealed that 70% of drivers preferred ADAS for their vehicles. While the preference and use of advanced features seem to increase, the question of whether drivers understand these technologies as expected still remains.

A survey by the American Automobile Association (AAA) revealed that 21% of vehicle owners assisted with BSW did not understand the limitations of the system while Fleet Manager expected the number to be about 80% [77] [78]. On the other hand, 33% of the vehicle owners did not understand that the sensors engaging the Emergency Braking System (EBS) could be blocked [77]. Also, 40% of drivers misunderstood the application of FCW believing that such a system would automatically apply brakes [78]. While the extent of driver understanding of ADAS is evident, what magnifies the issue of driver safety is their reliance on such systems. It was reported that 29% of the respondents to a survey felt comfortable engaging in other activities when provided with ACC, 30% did not do shoulder checks when provided with BSW, and 25% did not look back over their shoulder when provided with rear cross traffic alert [77].

There are anticipated advantages of the advanced features. The LKA and LDW were expected to mitigate over half a million crashes in 2016 alone [79]. The LKA uses sensors at regular intervals to determine if the vehicle unintentionally moves out of its travel lane and corrects the steering or other related aspects to maintain the vehicle in its travel lane [80]. It is expected to have significant effects on safety, especially on run-off and head-on crashes [81] [82]. It is estimated that a 100% effective lane departure prevention system could reduce single vehicle run off crashes by 65% [83]. While advantages are anticipated, tests and data also indicate limitations of the advanced features.

ACC and LKA were tested under multiple driving conditions by the Insurance Institute for Highway Safety (IIHS) in a series of track tests [84]. These tests revealed that ACC reacted aggressively in some scenarios while failing to react to already stopped vehicles [84]. Similarly, LKA was also observed to steer over the shoulder in some cases where the lanes were not detected [84]. Drivers understanding such implications and taking control of the vehicle when needed is, therefore, very important and influences their satisfaction as well as acceptance of the advanced features.

A survey conducted by Consumer Reports [85] revealed that 74% of the respondents were very satisfied with LKA while 85% of the respondents were very satisfied with ACC. While 65% of the respondents trusted LKA to work every time, ACC was trusted by 72% of the respondents [86]. Most tests related to ACC and LKA in the past were performed under safer conditions compared to real-world traffic conditions and with better trained drivers [86]. Also, it is possible that such systems make drivers more reluctant and less prompt when driving [86]. Further, a few consumers also complained of LKA not working properly at nighttime and during rain [86].

While it is difficult to precisely capture driver behavior in the real-world, there have been few research studies where drivers were provided with a test vehicle to capture and analyze driving behavior or by conducting surveys [87] [88]. Though these research studies captured some aspects of the driver understanding, they are limited to selected scenarios and may involve a long and cumbersome process. Privacy may also be a trade-off. Thus, it is imperative that automotive companies and researchers account for such aspects and conduct these tests in a diverse range of real-world conditions to assess where and when the advanced features might not yield expected outcomes.

Consumer Reports [89] considers ACC to be more of a luxury feature than a safety feature owing to its functionality. Providing ACC along with other ADAS may mask the minimal effectiveness of the system. Further, the efficient functioning of ACC seems to vary based on the automotive companies offering it [90]. ACC has been observed to be jerky with acceleration and braking maneuvers, and its response to already stopped vehicles was discussed to be one of its limitations. Additionally, it was observed that drivers with ACC were driving at higher speeds compared to drivers without ACC [91].

The ACC and LKA features in combination control both the longitudinal and lateral movements of a vehicle and provide a basis for a more advanced automated driving version. The reliability of drivers on these systems also plays a vital role in their effectiveness, as it dictates the attention they are paying while driving. Many studies have highlighted the direct impacts of these features. But a deeper understanding of their effects on driving behavior needs to be investigated.

7. Conclusions, Knowledge Gaps, and Need for Future Research

Extensive research was conducted on the effectiveness of advanced features in influencing driver behavior. Various methodologies have been adopted to investigate the effects of advanced features in a vehicle on driver behavior. Methodologies employing surveys and mathematical models are generally aimed to research the adaptability of the methods in modeling driver behavior, although a few researchers focused on studying the acceptance levels of different advanced features. A few researchers also focused on predicting driver behavior, which yielded reasonable results. However, these methods often rely on self-reporting and the participants could be biased when answering the questions, especially when they are being scrutinized by another person.

Field test methods were explored to capture driver behavior in some cases. A few researchers looked at the acceptance rates of different advanced features based on age and gender, while a few other researchers focused on the effect of advanced features on driving behavior. Similarly, driving simulator studies have been conducted to examine the effect of advanced features in certain conditions. Most of the driving simulator studies did not take demographic characteristics into consideration, nor did they compare participants from two demographic groups (for example, young and old). The less than anticipated levels of acceptance of the advanced features and safety implications raises concern and emphasizes the need for a comprehensive, thorough, independent, and unbiased research considering make, model, year of manufacturing, and the type of technology and functionality of each advanced feature.

A persisting gap was observed in the previous studies, which tend to be more hypotheses-driven, leading to concentrated research with reduced applicability. The other limitation of the past studies is the investigation of only one or two advanced features at a time. There is a need to capture driver behavior when using vehicles with advanced features, individually and together, in various real-world driving situations to derive meaningful conclusions and understanding affects in a multitude of cases.

The percentage of drivers relying on advanced features, the limitations that apply to various advanced features, and the lack of a thorough understanding of their implications can lead to many unsafe driving conditions. While the advanced features make driving tasks easier and comfortable, they may also make driving more difficult and sometimes result in unsafe situations. The advanced features take up certain driving tasks making a driver's job easier to some extent, but the driver needs to be cautious at all times to take over driving when needed or as soon as any of these systems fail to react or disengage. This brings forth the argument whether the advanced features lead to other unforeseen effects on drivers. Thus, there is a need to assess by evaluating the behavior of drivers using vehicles with advanced features and comparing with drivers using vehicles without advanced features in a diverse range of real-world driving conditions and scenarios (urban compared to rural, nighttime compared to daytime, icy/snowy compared to rainy compared to cloudy compared to normal weather, different types of curves/grades compared to straight/level sections, etc.) to better understand the driving patterns and safety implications.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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