



Preparing Next-Gen Drivers: The Roles of Standardised Terminology, Regular Training and Large Language Models in Driver Education for Autonomous Vehicles

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Doctor of Philosophy

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List of Abbreviations:

Abbreviation	Meaning
AAA	American Automobile Association
ACC	Adaptive Cruise Control
ADAS	Advanced Driver Assistance Systems
AFL	Adaptive Front Lighting
AHB	Automatic High Beam
AI	Artificial Intelligence
ANCAP	Australian New Car Assessment Program
ANOVA	Analysis of Variance
AP	AutoPilot
AV	Autonomous Vehicle
BSA	Blind Spot Assist
CA	Collision Avoidance
CC	Cruise Control
DARPA	Defence Advanced Research Projects Administration
LKA	Lane Keeping Assist
LLMs	Large Language Models
NASA-TLX	NASA Task Load Index
NHTSA	National Highway Traffic Safety Administration
RMSE	Root Mean Square Error
SAE	Society of Automotive Engineers
SD	Standard Deviation
SV	Subject Vehicle
T	Trigger

Abstract

The advancement of vehicular technologies towards autonomy necessitates a re-evaluation of driver interaction with Advanced Driver Assistance Systems (ADAS) and Autonomous Vehicle (AV) technologies. This thesis presents an integrated examination of the challenges and opportunities in enhancing driver understanding and interaction with these systems, focusing on terminology standardisation and transparency, the effectiveness of driver training, and the application of Large Language Models (LLMs) in driver education. Through a series of studies, this research seeks to enhance the integration of ADAS and AV technologies into society, ensuring safer roads and more informed users.

The research identifies a critical gap in the standardisation and transparency of terminology and operations in ADAS, highlighting a widespread disparity across manufacturers. This investigation reveals that terminologies that describe ADAS functions vary widely and often lack intuitiveness, contributing to confusion and underutilisation of safety features. The study advocates for the adoption of standardised terminology and clear operational guidelines to improve user comprehension and vehicle safety. These recommendations aim to provide essential insights for Artificial Intelligence (AI) experts and vehicle manufacturers, assisting the transport industry, regulators, and technology developers in designing comprehensive frameworks and guidelines to ensure consistent and effective communication of ADAS functionalities.

Further investigation evaluates the role of structured training programs in preparing drivers for the complexities of ADAS and AV technologies. Simulation-based studies show significant improvements in drivers' operational proficiency post-training, emphasising the necessity of formal education in enhancing road safety in the autonomous era. Training sessions' results involving novice and experienced drivers indicate that appropriate training significantly enhances drivers' accuracy and reaction times when interacting with ADAS and AV systems. This underscores the importance of tailored and continuous training programs.

The final area of study explores the efficacy of LLM-based instruction versus conventional training methods in educating drivers about ADAS and AV functionalities. Findings reveal that instruction via LLM, specifically through interactions with ChatGPT, significantly outperforms conventional training approaches regarding learning outcomes. Participants trained via LLM demonstrated quicker comprehension and higher consistency in activating and utilising ADAS functions than those trained through conventional methods. The findings further indicate that participants who engaged with ChatGPT-based training scored higher (on average, 21% higher) in accuracy in activating ADAS functions. A statistically significant reduction in activation time for all the functions was also observed, such that $P < 0.05$. This highlights the potential of integrating AI into educational frameworks for complex system operations.

Collectively, these research areas contribute to a comprehensive strategy to improve driver safety and efficacy in the era of autonomous vehicles. By advocating for standardised terminologies, effective training programs, and the innovative use of AI in education, this thesis lays the groundwork for future initiatives to ensure drivers are well-prepared for the evolving demands of vehicular technology. These insights offer valuable implications for policymakers, educators, the automotive industry, and the transportation industry, potentially improving global road safety and regulatory practices.

Chapter 1: Introduction

1.1. Background

The rapid advancement of sensing and Artificial Intelligence (AI) technologies in the automotive industry has led to the development of Advanced Driver Assistance Systems (ADAS) and Autonomous/Automated Vehicles (AVs), which hold the potential to revolutionise transportation systems [1, 2]. These innovations promise to enhance road safety [3], reduce traffic congestion, and improve overall mobility [1]. However, the successful integration of these technologies into societal frameworks is often obstructed by challenges associated with human factors, contributing to over 90% of road accidents [4].

Road traffic accidents remain a leading cause of fatalities and injuries globally, with more than twenty million incidents reported annually [5]. The consequences of these accidents extend beyond the loss of life, encompassing substantial economic burdens related to healthcare costs, lost productivity, and legal proceedings [6]. In Australia, thousands of individuals lose their lives or suffer injuries on the roads each year, reflecting a grim reality that mirrors the current situation globally [4]. The majority of these accidents can be attributed to human factors, such as speeding, distracted driving, intoxication [5, 7], and fatigue [5]. This compelling evidence indicates a critical need for solutions that target the root causes of these accidents.

The development of ADAS and AVs has emerged as a potential turning point in enhancing road safety by mitigating the risks associated with human error [8]. These technologies offer assistance or automation in driving tasks, with studies projecting that widespread adoption of ADAS could significantly reduce crashes, possibly up to 90% [8]. The Society of Automotive Engineers (SAE) has defined various levels of automation, ranging from no driving automation (level 0) to full automation (level 5) [9]. For details on their definitions, please refer to section 2.3. The capabilities

of AVs vary significantly across these levels, influencing their potential impact on safety and efficiency [9].

Despite the promising potential of ADAS and AVs, the path to realising their full benefits is fraught with challenges. Experts believe fully autonomous vehicles are still at least a decade away [2]. Numerous social, ethical, technical, infrastructural, and regulatory hurdles exist to overcome in the journey from partially autonomous to fully autonomous vehicles [10, 11]. According to the US National Highway Traffic Safety Administration (NHTSA), 94% of accidents are related to human negligence [10]. Modern cars with ADAS and AV functionalities are envisioned to reduce the number of crashes, pollution, and energy consumption [12]. The lack of standardised terminology for ADAS functions across car manufacturers poses a significant challenge in ensuring consistent understanding and usage of these technologies [13].

One of the most significant barriers to adopting ADAS and AVs is the general public's lack of understanding and familiarity with these systems. This limited engagement can be attributed to various factors, including a lack of perceived benefits, trust issues, functional limitations [3, 14, 15], a lack of legal framework [16], and an absence of user knowledge and experience [17, 18]. Furthermore, the seamless operation and utilisation of ADAS functions and AVs largely depend on drivers' comprehensive understanding and ability to control these advanced systems effectively. Several obstacles, such as the lack of standardisation, operational conditions of ADAS functions across manufacturers and the absence of specific training and practising platforms, hinder the development of these essential skills [19].

The historical adoption of fully automated elevators provides a valuable perspective on the potential trajectory of ADAS and AV technologies. Elevator technology took approximately fifty years to prevail and gain widespread public acceptance[20]. There is a consensus that today's elevators are safe. This example demonstrates a high level of similarity to the development and adoption of ADAS technologies in the automotive industry. It leads to questions on whether fully autonomous driving functionalities on top of ADAS may follow the same adoption trend. However, from the technological point of view, there are significant differences. While both are autonomous systems, elevators are designed for operating in a confined environment with mostly constant parameters. In contrast, ADAS needs to tackle dynamic environmental factors and unpredictable human behaviours, making

it hard to achieve the same safety level and gain the general public's trust. It is expected that the public will still take many years to fully embrace autonomous safety features in automobiles [2].

Another relevant example is the adoption of autonomous functions in modern aviation, which represents the other end of the spectrum. Unlike elevators, autopilot functions in modern planes are designed to operate in a dynamic environment, accounting for various factors such as headwinds, tailwinds, crosswinds, and turbulence [21, 22]. Similarly, modern ADAS functions incorporate sensors such as cameras, ultrasonic sensors, lidar, and radar that collect data [23]. These data are then processed using advanced signal processing and control algorithms to predict and mitigate potential crashes. It is anticipated that in the future, AV will leverage machine learning techniques to further reduce the need for human intervention [24, 25]. However, it is important to note that while planes and autopilot systems share a similar technological framework with ADAS and AVs, they are designed to be operated by highly qualified and experienced pilots [26]. Pilots undergo extensive training and are well-informed about the functions and limitations of their planes. In contrast, there are currently no specific requirements or training programs for drivers of vehicles equipped with ADAS or autonomous driving functions, which poses a potential hazard.

The research community has increasingly recognised the critical role of appropriate training in harnessing the full potential of AV technology [3, 27]. Effective training programs are crucial for fostering drivers' confidence and imparting the necessary skills to interact with advanced systems safely and proficiently [18, 28].

However, current training methods, from paper-based and video-based instructions to demonstration-based and trial-and-error techniques, often fail to provide a comprehensive and engaging learning experience. The conventional learning process for ADAS functions is indeed diverse, involving demonstrations by sales agents at dealerships [18], video-based instruction [3, 17], and self-study through the vehicle's user manual [29, 30]. However, these methods have their limitations. For instance, due to time constraints and the complexity of ADAS features, dealership sales agents might not fully cover all available functionalities, leading to a knowledge gap [31]. Furthermore, these agents may lack the necessary expertise to adequately explain the operation of ADAS [32], further widening this informational gap. Additionally, user manuals, although detailed, often require a high level of existing knowledge and considerable time to be effectively used [33].

All these issues are further compounded by the lack of interactive learning experience, which limits the effectiveness of these manuals [34].

Currently, there is a lack of a formal training platform specifically designed for drivers of modern vehicles equipped with ADAS functions [31]. The recent introduction of Large Language Models (LLMs) like ChatGPT marks a historic educational breakthrough [35, 36]. Several studies [1, 37-50] have evidenced the potential of LLMs, such as ChatGPT, in enhancing learning outcomes, learner motivation, engagement, customised support and output presentation, consistency and scalability in training across a wide range of industries, including automotive, transportation, aviation, maritime, medical, education, information system, and construction. However, to our knowledge, no comprehensive study discusses how an LLM-augmented approach can be employed as an effective training tool for ADAS functions or AVs.

LLMs have begun to be employed for training, highlighting their adaptability and expanding role beyond their initial text generation function. These models can revolutionise how we approach learning and training by providing personalised, interactive, and adaptive learning experiences [51]. Specifically, in the context of driver training for ADAS and AVs, LLMs can be leveraged to develop engaging and effective training programs. These programs are designed to accommodate individual learners' unique needs and preferences, thereby significantly enhancing the overall effectiveness of the training process. The use of LLMs in driver training offers several advantages over conventional methods. LLMs can enhance the learning experience by providing an interactive and engaging platform where learners can ask questions, receive immediate feedback, and engage in meaningful dialogues with the AI system. This interactive approach helps learners better understand and retain the information presented. Additionally, LLMs can adapt to individual learners' needs and preferences by customising the content and pace of the training to meet their specific requirements. This personalised approach ensures that each learner receives the most effective training possible.

In addition to providing personalised and interactive learning experiences, LLMs can also be used to develop standardised training programs that ensure consistent and comprehensive coverage of all relevant topics and skills. By leveraging LLMs' vast knowledge base and natural language processing capabilities, training programs can be designed to cover all essential aspects of ADAS and AV operation, including system functionality, limitations, and best practices for safe and effective use.

Despite the substantial potential benefits that LLMs offer in driver training, it is essential to consider their inherent challenges and limitations. A primary concern is the accuracy and reliability of these models' information. As with any AI system, the effectiveness of LLMs is highly dependent on the quality of the training data. Moreover, LLMs encounter specific limitations, notably issues related to conversational continuity. These include challenges in resuming interactions after breaks or starting new sessions, attributed to the models' lack of sustained conversational memory [52].

Additionally, limitations arise when the dialogue reaches the maximum token capacity, potentially providing irrelevant or incorrect information [53]. The ability of LLMs to handle requests for real-time or very recent data is also notably inadequate [42], further restricting their utility in dynamic training. These factors collectively necessitate a cautious approach to the integration of LLMs in practical applications where reliability is critical.

1.2. AIM of the Thesis

This thesis investigates the critical importance of standardising the terminology and enhancing the transparency of operational conditions and procedures for ADAS functions in modern vehicles. This involves revealing the variable naming conventions and operational modalities across different manufacturers, aiming to foster a uniform understanding that can aid consumers in safely utilising these technologies.

This thesis aims to address the gap in the existing literature by investigating the influence of training on participants' abilities to interact with modern vehicles equipped with ADAS functions and to prepare them for operating AVs in the future. The primary objective is to determine whether end-users of ADAS and autonomous driving features require rigorous training comparable to that of aircraft pilots and ship captains to operate these functions safely. Additionally, the study explores the necessity of multiple training sessions for drivers to develop their procedural and cognitive skills and to understand the effect of repeated sessions on their performance. Furthermore, the research examines whether experienced drivers require less training than novice drivers to effectively utilise ADAS functions and whether regular use diminishes the need for repeated training.

To achieve these objectives, this thesis proposes a systematic framework for using LLM, particularly ChatGPT, as a training tool for drivers to use ADAS functions and AVs in the future. By leveraging the cognitive and dialogic capabilities of the LLM-augmented approach, the research aims to

enhance users' understanding of ADAS, thereby improving their interactions with these systems and ensuring safer and more efficient driving experiences. The efficacy of the ChatGPT-based training approach is evaluated through an empirical study and compared with conventional training methods for operating ADAS functions. Participants' performance, as measured by their accuracies and reaction times in interacting with ADAS functions, serves as primary metrics for assessing the effectiveness of different training methods. By investigating the cognitive underpinnings of learning and understanding ADAS functions, this research seeks to reveal how different training methods can influence the formation of mental models, thereby impacting the utilisation of ADAS functions.

The findings of this study hold significant implications for both the automotive industry and educators, offering practical strategies for ADAS training that can be incorporated into driver education programs, dealership demonstrations, and user manuals. As the automotive landscape continues to evolve towards increased automation, these systems' complexity often exceeds the understanding of ordinary drivers. Consequently, there is a critical need to reassess and refine training methodologies to ensure drivers are adequately equipped to handle these advanced systems. Integrating LLM into the training process could streamline the learning experience, enabling drivers to recall and utilise complex functions more effectively. This approach enhances comprehension of ADAS functions and promotes safer driving experiences in an increasingly automated era.

This thesis contributes to the growing knowledge of ADAS and AV technologies. It also advances the understanding of how these systems can be safely and effectively integrated into the automotive landscape. By addressing the critical issue of driver training, this research enriches the existing literature on adopting and utilising these technologies and develops an innovative LLM-augmented training approach. Through comprehensive investigations into the impact of training on participants' performance, this study offers valuable insights and recommendations for the automotive industry, policymakers, and educators. By enhancing training methodologies, fostering better standardisation, and utilising cutting-edge AI technologies, this research ensures that drivers are adequately prepared to interact with advanced technologies, thereby taking a significant step towards realising the full potential of ADAS and AVs in enhancing road safety and transforming transportation systems worldwide.

1.3. Research Questions

Q1: *How does the lack of standardisation and transparency in the ADAS function's nomenclature and operational conditions across various automakers affect drivers' utilisation and potential misuse of these functions?*

- How does maintaining transparency and consistency in AVs' functionality descriptions impact their safety and user trust?
- To what extent do terminologies used to describe ADAS functions vary across automobile manufacturers, and how does this variation impact driver understanding and utilisation of these functions?
- How do operational conditions and control procedures of ADAS functions vary across different car models, and what confusion or challenges do these variations pose to drivers?

Q2: *How important is it for AV drivers to have regular training? How does regular training influence the proficiency and safety of drivers interacting with ADAS and AV functions?*

- Why is it important to provide extra training for AV drivers, and what should be included in training?
- How does training effectiveness vary between novice and experienced drivers in enhancing their interaction with ADAS and AV functions?
- How does the effectiveness of training vary between frequent users of ADAS functions compared to those who have never used ADAS functions while driving in real life?
- After how many training sessions do drivers demonstrate a significant improvement in their accuracy, reaction time, and overall control when using ADAS functions?

Q3: *What could be the best training method for ADAS and AV drivers?*

- What would be an effective framework for preparing a ChatGPT prompt for training?
- How effective are LLM-based platforms in conveying complex ADAS functionalities compared to conventional training methods?
- How can LLM-based platforms like ChatGPT enhance the training process for ADAS and AV drivers?

Chapter 2: Literature Review

This chapter introduces crucial concepts and reviews, relevant literature on ADAS and AV technologies' development and training methodologies. Section 2.1 explores the early developments in AV technology, tracing the historical advancements that have paved the way for modern innovations. Section 2.2 examines the phases of technological evolution, detailing the significant milestones and breakthroughs in the field.

Section 2.3 provides a comprehensive overview of the various levels of automation, offering insights into the classification and capabilities of AV systems. The role of training in adopting ADAS and AVs is discussed in Section 2.4, highlighting the importance of effective training programs for drivers and operators. Section 2.5 examines the challenges and requirements in the automotive sector's training landscape, identifying the key factors influencing training initiatives' effectiveness.

Section 2.6 reviews the different training methodologies employed for ADAS and AVs, discussing the strengths and limitations of each approach. Section 2.7 explores the role of LLM in AV and ADAS training, illustrating how advanced AI techniques can enhance training programs. Finally, Section 2.8 summarises the chapter, synthesising the key points and setting the stage for the subsequent discussions in this thesis.

2.1. Autonomous Vehicles Early Developments

The concept of AVs can be traced back to the 15th century. In 1480, Leonardo da Vinci designed a self-propelled cart powered by high-tension spiral springs that could travel along a predetermined path, making it one of the first automated mobile vehicles in history [54]. In the 1920s, the 'Phantom Auto,' a pioneering example of a driverless car, was unveiled in a public demonstration. Developed by the Houdina Radio Control Company, this innovative vehicle was equipped with radio control technology, allowing it to operate remotely without a driver [55, 56]. Although primarily a theatrical

gimmick, the Phantom Auto captured the public's imagination and served as an early precursor to today's self-driving cars, foreshadowing at the potential of AV technology [57, 58].

In 1933, Wiley Post's "Mechanical Mike" autopilot system used gyroscopes to collect data from all three dimensions, enabling simultaneous flying and navigating. These gyroscopes have proven transformative in the development of AV and are still used today [54]. In the 1960s, as AI emerged as a field of study, visionaries started conceptualising cars that could navigate autonomously without human intervention [59, 60]. One notable example was the "Stanford Cart," developed by James Adams at Stanford University in 1961[54, 55]. The Stanford Cart was a wheeled robot that could autonomously navigate a room filled with obstacles using a camera and a computer. While it was not a car, the Stanford Cart demonstrated the potential of AI in autonomous navigation [54]. The late 1980s marked a significant milestone in AV development when Ernst Dickmanns and his team at the Bundeswehr University Munich successfully demonstrated the VaMoRs Mercedes Van [61]. The VaMoRs van was equipped with cameras and computer vision technology that allowed it to autonomously navigate at speeds up to 96km/h on empty streets [56, 61]. This groundbreaking achievement showcased the feasibility of autonomous driving and inspired further research in the field [58, 62].

2.2. Phases of Technological Evolution

Technological evolution in AVs can be distinctly segmented into three phases, each marked by pivotal developments and shifts in research focus, regulatory frameworks, and market readiness. Phase 1 encompasses the foundational research and the initial application of intelligent systems within vehicles and infrastructure. Phase 2 highlights the transformative impact of competitive innovation through the DARPA Challenges, fostering rapid advancements in autonomous capabilities. Phase 3 captures the integration of these technologies into consumer markets and the expansion of global regulatory acceptance. This phased approach provides a structured timeline to understand the progressive maturity of AV technology.

Phase 1 (1960-2003):

During this phase, research on AVs was divided into two directions. One of the early attempts focused on intelligent infrastructure, such as Automated Highway Systems (AHS). AHS projects aimed to create dedicated lanes for AVs, using embedded sensors and communication systems to enable

vehicle platooning and traffic management [61]. Researchers between 1960 and 2003 were mainly divided into two groups. The former group focused on the utilisation of intelligent road infrastructure to build an automated highway system, e.g. to achieve platooning with the use of inductive cable embedded under highways and magnets on cars. A 12.5 km length of California's highway I-15 has been modified for technological demonstrations [61]. One notable example was the Partners for Advanced Transit and Highways (PATH) program in California, which demonstrated vehicle platooning using magnets embedded in the roadway [63]. The second research group, including Ernst Dickmanns, focused on only sensing and intelligent technologies installed on the subject vehicle [56]. Pioneers like Ernst Dickmanns in Germany and the NavLab team at Carnegie Mellon University in the US made significant advancements in computer vision, sensor fusion, and autonomous navigation [64, 65]. The NavLab 5 vehicle, developed by Carnegie Mellon University, completed a cross-country journey from Pittsburgh, Pennsylvania, to San Diego, California, covering approximately 3,000 miles in 1995, demonstrating the potential of autonomous driving technology. [65, 66].

Various ADAS functions were also developed and introduced during this phase in consumer vehicles. These systems, such as Adaptive Cruise Control (ACC), Lane Keeping Assist (LKA), and Collision Warning (CW), laid the foundation for more advanced autonomous driving features [67]. The development of cruise control in the 1940s and 1950s by Ralph Teetor of Dana Corp. was a significant advancement, as it autonomously regulated vehicle speed and improved fuel economy [68]. For example, Toyota first developed ACC in 1998, and laser-based technology was used due to its compact form factor and low cost. A year later, in 1999, Jaguar developed their ACC system, and they preferred to use radar-based technology because of its long-range [67]. Over the years, automakers have used different technologies to implement their own ADAS functions. Due to a lack of consensus among manufacturers, automakers have used different functions and names for marketing their products [13]. The lack of standardisation imposes many challenges in adopting and utilising ADAS functions, which are further presented in Chapter 3. The invention of Light Detection and Ranging (LIDAR) in the 1960s was another crucial development. LIDAR creates a three-dimensional map around the vehicle by sending laser pulses to remote objects, enabling AVs to perceive and respond to their environment in real-time [54]. Along with modern GPS systems, LIDAR represents one of the most enabling technologies for the recent momentum in the AV industry [54].

Phase 2 (2003-2007):

The Defence Advanced Research Projects Agency (DARPA), an agency of the US Department of defence, organised the DARPA Grand Challenges, which played a pivotal role in accelerating the development of AV technology [61]. The first Grand Challenge, held in 2004, required driverless vehicles to navigate a 150-mile off-road course in the Mojave Desert [69, 70]. In the competition, the best contesting vehicle could only complete 12km out of 230km of the course without having a collision, indicating the technology's incompetence at that time. Although no vehicle completed the full course, the competition generated significant interest and investment in AV research [69, 70].

The second Grand Challenge, held in 2005, saw a remarkable improvement in AV performance. Five vehicles successfully completed the 132-mile desert course, with Stanley, the winning vehicle developed by Stanford University, finishing the race in just under seven hours [71]. In 2007, DARPA introduced the Urban Challenge, which required driverless vehicles to navigate a complex urban environment while adhering to traffic rules and interacting with other vehicles. Six teams successfully completed the 60-mile urban course, demonstrating the feasibility of autonomous driving in real-world conditions [72, 73].

Phase 3 (2007-Present):

The DARPA competitions paved the way for the development of modern ADAS and strengthened the partnership between industry and academia. The DARPA competitions further attracted tech giants like Google to invest in AVs. In many years of Google's on-road experiments, only one incident happened, on 14th Feb 2016, that was due to the fault of the AV [12]. Google's Self-Driving Car project, later known as Waymo, began testing its AV on public roads in 2009. By 2016, Waymo's fleet had logged over 2 million miles of autonomous driving [74]. In 2015, Tesla introduced its AutoPilot (AP) system, which provided semi-autonomous driving capabilities to its vehicles [75]. Traditional automotive manufacturers also joined the race to develop self-driving cars. Companies like Tesla, BMW, Mercedes, General Motors, Ford, Waymo, Audi, Toyota, Nissan, and Honda formed partnerships with technology firms and startups to accelerate their AV development efforts [76].

Governments and regulatory bodies also began to adapt to the rapid advancements in AV technology. Several countries, including the United States, Germany, and Japan, introduced legislation and guidelines to facilitate the testing and deployment of AV on public roads [61]. As of 2023, AVs are being tested and deployed in various pilot projects and limited commercial services around the world.

While fully autonomous vehicles (Level 5) are not yet available to the general public, the industry continues to make significant strides toward realising the vision of driverless transportation [54].

2.3. Levels of Automation

The SAE defines vehicle automation levels ranging from 0 (no automation) to 5 (full automation). This classification standardises the capabilities and expectations of ADAS and AV, clearly delineating the responsibilities between drivers and automated systems. These guidelines are crucial for manufacturers and consumers to understand the functionality and operational expectations at each level of automation [9].

Level 0- No Automation: At Level 0, the human driver always performs all driving tasks without assistance from the vehicle's systems. Features at this level, such as emergency braking alerts and blind spot warnings, serve only to inform the driver through passive warnings; they do not perform any control functions over the vehicle [9, 77].

Level 1- Driver Assistance: Vehicles at Level 1 automation can assist the human driver with steering, acceleration, and deceleration based on information about the driving environment. The driver remains fully engaged in all other aspects of driving. Technologies at this level include ACC and LKA, which independently help manage the vehicle's speed or lane position [9, 77].

Level 2- Partial Automation: At Level 2, the vehicle can simultaneously control steering and acceleration/deceleration in certain scenarios, such as on highways. However, the driver must remain fully engaged and ready to intervene and take over the driving task at any moment. Common functionalities include ACC combined with LKA, which works together to navigate certain traffic situations [9, 77].

Level 3- Conditional Automation: Level 3 vehicles can perform all driving tasks and monitor the environment in specific conditions, such as within geo-fenced areas or particular types of roads. The human driver must be ready to intervene when the system requests, providing a safety net during transitions of control. This level expects drivers to be prepared to regain control with sufficient transition time [9, 77].

Level 4- High Automation: Vehicles with Level 4 automation can perform all driving tasks and monitor conditions in certain predefined environments without human input. These vehicles can operate

autonomously in controlled areas like cities adapted for autonomous driving or during specific conditions set by the manufacturers. No human attention is required when the system operates within its set parameters [9, 77].

Level 5- Full Automation: At Level 5, the vehicle achieves complete automation and can perform all driving functions under all conditions without any human intervention. These vehicles can handle all environments and roadway conditions a human driver could manage, encompassing the full spectrum of autonomous operations [9, 77].

2.4. The Role of Training in the Adoption of Advanced Driver Assistance Systems and Autonomous Vehicles

The emergence of AV technology and ADAS marks a significant development towards enhancing road safety. However, these technologies introduce substantial challenges, primarily due to the general public's limited understanding of their operational mechanics and constraints. Effective use of AV and ADAS requires traditional driving skills, and a deep comprehension of the technologies involved. This includes knowledge of the SAE levels of automation and an understanding of driver responsibilities across different scenarios [27, 78].

Extensive research in aviation, maritime, and medical sectors supports the idea that continuous training can improve end-users real-world performance [79]. Training requirements vary across different industries, reflecting each field's unique demands and complexities. For instance, pilots must complete 1500 hours of flight time to obtain an air transport pilot licence [26], and they need to periodically refresh their training skills, with the frequency of training dependent on factors such as the type of aircraft and accumulated flight hours [80, 81]. Similarly, in the maritime industry, crew members must undergo comprehensive training and regularly update their skills, as evidenced by the requirement to conduct weekly drills for the operation of watertight doors, valves, and closing mechanisms of scuppers [82]. Training is crucial for ensuring the safe operation of technology, particularly when changes are made to the interface of an instrument [19].

2.4.1. Case Studies from Aviation Demonstrating the Impact of Specialised Training

Case Study 1: US Airways Flight 1549 - Miracle on the Hudson (January 15, 2009):

Event Description: On January 15, 2009, Captain Chesley “Sully” Sullenberger and First Officer Jeffrey Skiles executed an emergency water landing in the Hudson River after a bird strike disabled both engines shortly after take-off [83]. This incident demonstrated the pilots’ ability to handle unprecedented emergency situations [84].

Training Impact: The pilot’s expert aircraft handling following the bird strike was possible due to rigorous and structured training for emergency scenarios, including flight simulators covering water landings and engine failures [84]. Systems equipped in modern aircraft are designed for operation by highly qualified and experienced pilots, which was pivotal in this event. This successful emergency landing with no loss of life underscored the vital role of structured training in emergencies, highlighting the importance of preparedness and expertise [84].

Case Study 2: British Midland Flight 92 (January 8, 1989):

Event Description: On January 8, 1989, British Midland Flight 92, a Boeing 737-400, encountered a critical situation shortly after take-off. The aircraft suffered a fan blade failure that resulted in severe vibration and visible smoke within the flight deck [85]. This mechanical issue quickly led to confusion among the crew concerning which engine had malfunctioned. Due to the crew’s misunderstanding of the aircraft’s new design and the misinterpretation of the electronic instrument readings, the first officer mistakenly advised shutting down the functioning engine instead of the damaged one. This decision ultimately caused the aircraft to crash near Kegworth, England [85, 86].

Training Impact: The investigation into the crash revealed significant training deficiencies concerning the Boeing 737-400’s new model, particularly in identifying and managing engine malfunctions [85, 86]. The crew’s lack of familiarity with the aircraft’s updated design and the non-intuitive nature of the electronic indicators were critical factors in the crash. The first officer’s failure to correctly assimilate the electronic instrument readings exacerbated the situation, leading to the erroneous shutdown of the operational engine, underscoring the inadequacies in training regarding the handling of new aircraft technologies [86].

2.4.2. Lessons for AV Training from Aviation Catastrophes:

The significance of training extends beyond traditional vehicle operation to include mastery over modern vehicles equipped with ADAS and AV functionalities. Comprehensive training programs are crucial for preparing operators for rare but potentially catastrophic scenarios where automation might fail [86]. Modern vehicle drivers should be proficient in understanding and operating specific automated systems, such as ACC, LKA, and other ADAS functionalities available in modern vehicles. Training should encompass both emergency management and in-depth knowledge of how these systems work, including when and how to engage or disengage them safely. Understanding the intricacies of these technologies is crucial, much like pilots becoming proficient in using autopilot and other automated systems in aircraft. Ensuring automation's safe and effective use in high-stakes environments is essential.

This lesson underscores the importance of comprehensive training for operators of technologically advanced systems, whether in aviation or automotive contexts. Just as pilots must thoroughly understand aircraft systems and emergency procedures, drivers of vehicles equipped with ADAS must be well-versed in their functionalities and limitations. Training should emphasise routine operation and the correct response to system failures and unexpected scenarios. This ensures that all operators have the knowledge and skills necessary to make informed decisions during critical moments. This dual focus on procedural and system-level understanding is crucial for maximising safety and effectively utilising advanced automotive technologies. It parallels the need in automotive industries to ensure that drivers can interpret and respond to the data and alerts provided by systems like ACC and LKA under all conditions.

2.5. Challenges and Requirements in Automotive Sector Training

Training drivers for ADAS and AV technologies present unique challenges in the automotive sector. The diversity of interface layouts across different automakers adds complexity, requiring customised training strategies. These strategies are essential to ensure drivers can effectively operate a variety of systems. The diversity of interface layouts across different automakers adds complexity, requiring customised training strategies to ensure drivers can effectively operate a variety of systems [19]. Procedural skills are necessary for utilising driving assistance functions, such as activating ACC, LKA, and CA. Furthermore, a thorough understanding of the SAE levels of automation, system limitations,

and drivers' responsibilities is essential [27, 78]. Conventional training methods, which often rely on textual manuals and basic instructions, are increasingly proving to be inadequate. Such methods do not adequately impart the necessary knowledge and skills required for safe operation [27]. This inadequacy highlights the urgent need for more comprehensive training programs. These programs should enhance procedural skills and foster higher-order cognitive abilities, such as situational awareness and risk assessment [33, 87].

The research underscores the importance of training programs that develop both procedural and higher-order cognitive skills for the safe use of ADAS and AV technologies. Adequate knowledge of system capabilities and limitations can significantly enhance driver performance and proficiency in using automation systems [87, 88]. Moreover, continuous training is vital across various industries to maintain proficiency and adapt to evolving technological demands. The importance of tailored training is particularly paramount in the context of new and complex systems like those found in vehicles equipped with ADAS functions. Differences in interface layouts among automakers can further complicate the operation of these systems, underscoring the need for specific training tailored to these unique demands [19].

2.6. Training Methodologies for ADAS and AVs

2.6.1. Current Training Practices

The automotive industry employs various training methodologies to educate drivers on using ADAS and AVs. These training practices range from conventional methods, such as user manuals [29, 89] and demonstrations at dealerships [30, 90], to more modern approaches, like multimedia resources [88] and hands-on experience [91]. One of the most common training methods is the use of user manuals. Vehicle manufacturers provide detailed manuals that explain the functionalities, capabilities, and limitations of ADAS and AV systems. However, studies have shown that many drivers do not read these manuals thoroughly, leading to a lack of understanding and misuse of the systems [29]. For example, [91] found that most drivers in their study did not read the user manual to learn about the technology in their vehicle, relying instead on a more dangerous 'trial and error' learning method.

Physical demonstrations at dealerships are another conventional training method. Car dealers often provide buyers with brief demonstrations of ADAS and AV features during purchase [30]. While this approach can be helpful, it is usually limited by time constraints and may not cover all the essential aspects of the systems. Furthermore, the inconsistency of training materials and terminology between different vehicle manufacturers may also contribute to challenges in learning these systems [32]. Multimedia resources, such as videos and informational brochures, have gained popularity as a training tool for ADAS and AVs. These resources can provide a more engaging and accessible way for drivers to learn about the systems [3]. For example, some manufacturers have created online video tutorials that explain the functionalities and proper usage of ADAS features [92]. Studies have shown that video-based training can effectively teach complex concepts and procedures, especially when designed according to multimedia learning principles [93, 94]. Video tutorials can utilise multimodal presentation, highlighting techniques, and segmentation to enhance learning outcomes compared to conventional text-based instructions [93].

Hands-on experience through trial and error is another common training method. Many drivers learn to use ADAS and AV systems by experimenting with them while driving [18]. While this approach can be effective in familiarising drivers with the systems, it can also lead to unsafe situations if the driver is not fully aware of the system's limitations [89]. The importance of training in developing accurate mental models of ADAS functions such as ACC and LKA was highlighted by [95]. Participants who underwent a training program reported significantly higher levels of perceived understanding and confidence compared to those who did not receive training. Table 2.1 demonstrates current training practices for ADAS and AVs in the automotive industry.

Table 2.1: Current training practices for ADAS and AVs in the automotive industry

Training Method	Description	Advantages	Disadvantages
User Manual driver [29-31, 33, 91, 96, 97]	User manuals offer in-depth explanations and step-by-step instructions for understanding and operating ADAS and	Provides comprehensive information; Allows self-paced learning; Serves as a reference for future use.	Drivers often do not read thoroughly; complex technical language may hinder understanding; it demands a high literacy

	AV features, ensuring users can utilize these systems safely and effectively.		level; and it lacks interactive learning experiences.
Demonstration at Dealership [18, 30-32, 90]	Car dealers provide brief, hands-on demonstrations of ADAS and AV features to buyers during the vehicle purchase process	Offers personalised guidance; Provides hands-on experience and immediate feedback; Gives drivers the opportunity to ask questions.	Demonstrations are often brief, potentially omitting essential details due to strict time constraints and legal considerations; Inconsistency in training materials: Variability in the materials and terminology used across different manufacturers can lead to a lack of standardisation in training; Risk of inaccurate information: Dealers may provide incorrect details if they lack in-depth technical knowledge of ADAS functionalities.
Multimedia Resources [3, 17, 31, 93, 94]	Videos, animations, and informational materials explaining system functionalities and proper usage. It can be accessed online or through dedicated applications.	Engaging and accessible; Can utilise multimodal presentation, highlighting, and segmentation to enhance learning; Allows for self-paced learning and review.	It may not provide hands-on experience, requires access to technology (e.g., internet, devices), and may vary in quality and accuracy of content.

Trial and Error [18, 31, 89, 95, 97]	Trial and error training involves drivers experimenting with ADAS and AV systems in real-time while driving to gain firsthand experience and understanding of their functionality.	Familiarises drivers with the systems; Provides hands-on experience; Facilitates learning in real-world contexts.	Can lead to unsafe situations if not aware of system limitations; May foster incorrect mental models; Lacks structured guidance and feedback.
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In conclusion, the current training practices for ADAS and AVs in the automotive industry encompass a variety of methods, each with its own advantages and disadvantages. As these technologies continue to evolve, developing more effective and standardised training approaches is crucial to ensure drivers' safe and proper use of these systems. Research has shown that comprehensive training, incorporating both procedural skills and higher-order cognitive knowledge, can lead to better understanding and usage of ADAS and AVs [78, 88, 98].

Moreover, the effectiveness of different training methods may vary depending on the target audience. For example, younger and older drivers typically differ in their understanding and interactions with vehicle automation, with older drivers often preferring to learn at the dealership or through owner's manuals, while younger drivers favour on-road trial and error [32]. It has been found that gender may also influence ADAS training preferences among older drivers, with male drivers benefiting more from simulator-based training and female drivers benefiting more from video-based training [3].

Given the importance of proper training for the safe and effective use of ADAS and AVs, policymakers, vehicle manufacturers, and driver education institutions must collaborate to develop comprehensive and tailored training programs. These programs should incorporate conventional and modern training methods, considering different driver populations' diverse needs and preferences. By ensuring that drivers receive adequate education and training on these advanced technologies, we can work towards realising the potential safety benefits of ADAS and AVs while minimising the risks associated with their misuse or lack of understanding.

2.7. The Role of LLM in AV and ADAS Training

The emergence of LLMs like ChatGPT has opened new possibilities for enhancing training methodologies across various domains, including the automotive industry. The integration of LLMs into training programs for ADAS and AVs offers several benefits that can significantly improve learning outcomes, engagement, and personalised support for drivers and operators. Recent research has demonstrated the potential of LLMs in enhancing learning experiences and outcomes across a wide range of industries. For instance, in the healthcare sector, ChatGPT-based medical training simulations have shown promise in improving learner engagement and understanding [46]. In education, LLMs have been utilised to create adaptive learning systems that provide personalised tutoring, tailoring the complexity of training scenarios to learners' performance [42]. Moreover, domain-specific LLMs, such as AviationGPT, have been developed to support continuous learning platforms for aviation professionals, enabling ongoing professional development as new technologies emerge [99]. Moreover, LLMs can help develop accurate mental models necessary for effectively operating advanced in-vehicle systems. The importance of mental models in the context of ADAS and AV training is highlighted by recent research [15, 100]. The use of LLMs in manufacturing has demonstrated their potential to enhance training for complex machinery operations [41]. Furthermore, studies across various industries, such as finance, have shown that LLMs can improve learning outcomes, engagement, and personalised support [43, 48, 49].

The benefits of LLMs in AV and ADAS training are particularly significant due to these technologies' complex and rapidly evolving nature. LLMs can help drivers and operators develop the necessary skills and mental models to use these systems safely and effectively by creating interactive, adaptive learning environments that can be updated in real-time. For example, LLMs can generate scenario-based dialogues and simulations that expose learners to a wide range of real-life situations they might encounter while using ADAS or AVs. These scenarios can be dynamically adjusted based on the learner's performance, ensuring that each individual receives a personalised learning experience tailored to their needs and skill level [39]. This adaptive approach enhances engagement and promotes a deeper understanding of the systems' functionalities and limitations, which is critical for safe operation [44]. As ADAS and AV technologies continue to advance, LLMs can support continuous learning by updating training modules in real-time to reflect the latest developments and best practices [101]. This ability to provide ongoing professional development is particularly valuable in

the automotive industry, where staying up to date with the latest technologies is essential for maintaining a competitive edge and ensuring customer safety.

Despite the growing body of evidence supporting the use of LLMs in various industries, to our knowledge, no comprehensive study has specifically explored how an LLM-augmented approach can be employed as an effective training tool for ADAS functions or AVs. The potential of LLMs to enhance training methodologies in the automotive industry, particularly in the context of ADAS and AVs, presents a significant opportunity for further research and development. In conclusion, integrating LLMs into AV and ADAS training programs offers numerous benefits that can significantly enhance the learning experience for drivers and operators. By creating interactive, adaptive learning environments that can be continuously updated, LLMs have the potential to revolutionise how training is conducted in the automotive industry and beyond. As these technologies continue to evolve, organisations need to explore and leverage LLMs' capabilities to develop a skilled and knowledgeable workforce capable of safely and effectively operating advanced in-vehicle systems.

2.8. Chapter Summary

This chapter provides a comprehensive overview of the evolution of ADAS and AV technology, tracing its development from early conceptualisations in the 15th century to today's sophisticated systems. The discussion began by reviewing historical milestones, such as Leonardo da Vinci's self-propelled cart and the introduction of the 1920s 'Phantom Auto', culminating in the complex modern-day ADAS and AVs. The chapter details the phases of AV development, distinguishing between early experiments and modern achievements in automation, and includes the pivotal role of DARPA Grand Challenges in advancing autonomous navigation. It further explored the standardised levels of vehicle automation defined by the SAE, delineating the functionalities and responsibilities at each level, from no automation (Level 0) to full automation (Level 5). Following this, the importance of training for the effective adoption of AV and ADAS technologies is emphasised, analysing current training methodologies within the automotive industry. The potential enhancements possible through integrating LLMs like ChatGPT, which could offer more adaptive and personalised training experiences, are discussed. This discussion addressed the challenges in public adoption and underscored the necessity for comprehensive training to ensure safety and efficiency in AV operations. By highlighting both the historical context and technological progression of AVs, the chapter emphasised the importance of continuous advancement in training methods to ensure these

systems' safe and effective integration into society. It also identified gaps in current research and training practices, setting the stage for further exploration in subsequent chapters. This holistic review recounts AV technology's journey and serves as a precursor to the detailed experimental and practical applications discussed later in this thesis.

Chapter 3: Standardising ADAS Naming and Operations

This chapter explores a pivotal study on the importance of standardising and maintaining transparency in ADAS's nomenclature, designs, and operations in vehicles transitioning to full autonomy. In this study, a systematic review of user manuals from various brands is conducted, and common ADAS functions found in modern vehicles are critically analysed. Significant variations in how these functions are named and operated across different manufacturers are identified. The study reveals that such inconsistencies can lead to confusion among drivers, underutilisation of ADAS features, and potential misuse. The findings emphasise the need for industry-wide consensus on terminology, operational conditions, and control procedures. By establishing clear guidelines, stakeholders such as transport industry leaders, AI experts, and regulators can enhance the safety and efficacy of both current ADAS and future autonomous driving technologies. This chapter discusses these findings and their implications for developing regulatory frameworks to govern the evolution of vehicle automation.

3.1. Introduction

The pursuit of self-driving vehicles faces diverse challenges across social, ethical, technical, infrastructural, and regulatory domains [10, 11]. While experts predict a decade may still be required before driverless vehicles dominate our roads, the role of ADAS is increasingly pivotal [2, 102]. As a key segment in automotive electronics, ADAS is celebrated for its capability to reduce road accidents significantly. By 2025, it is anticipated that all modern vehicles will feature at least one ADAS function, marking a significant milestone in the automotive industry's quest to enhance road safety [103]. According to the U.S. NHTSA, 94% of traffic accidents are attributed to human error, underscoring the transformative potential of ADAS to mitigate such incidents and also reduce environmental and energy impacts [10, 12]. Despite these advancements, the absence of standardised ADAS

terminology across car manufacturers highlights ongoing challenges in achieving universal effectiveness and understanding [103].

Building upon the historical precedents discussed in Chapter 1 related to autonomous systems, this chapter focuses specifically on the automotive sector's unique challenges and technological demands. ADAS must operate in highly unpredictable and dynamic conditions, which significantly complicates the establishment of standardised safety protocols necessary for widespread acceptance. These complexities are concisely illustrated in Table 3.1, which highlights the differences in operational environments and training requirements between various autonomous systems. This comparison further emphasises the nuanced requirements of ADAS, underscoring how these systems diverge from other autonomous technologies in terms of complexity and safety considerations.

Table 3.1: Autonomous system - similarities and differences

Autonomous systems	Elevator	Vehicles (w/ADAS or fully autonomous)	Planes (w/autopilot functions)
Human operator/driver	A reasonable person	A reasonable person	Professional
Operational environment	A confined/static environment	A highly dynamic environment	A highly dynamic environment
Training requirements	No training required	Basic training required	Extensive training and assessments required

As demonstrated in the previous examples, there are a number of challenges and potential risks in the adoption of ADAS and autonomous driving functions in modern cars, i.e. training requirements, system limitations, and extrinsic dynamic factors, including traffic conditions, pedestrians, and other road users [2]. Therefore, it becomes the automotive industry's and its regulators' prime responsibility to clearly define standards for ADAS and autonomous driving technologies to achieve consistency across manufacturers. This can help expedite AV designs and development processes, gain the trust of the public, and yield a higher adoption rate.

In choosing different brands of sedan cars, we have focussed on maximising the overall geographical coverage while brands sharing the same parent company have been discarded. For manufacturers with luxury vehicle divisions, car models from the more luxurious production line are selected as they are equipped with more advanced ADAS functions. To ensure a fair comparison, the latest face-lifted sedans and their top-of-the-line versions have been selected for study whenever possible as they are

equipped with their manufacturers' most completed ADAS functions. The study is based on data collected from the latest user manuals and/or specifications obtained from the corresponding official car manufacturers' websites at the time of writing. Table 3.2 shows the list of vehicles that have been selected for this study.

Table 3.2: Vehicle brands and their parent organisations

Brand	Parent Organisation [104]	Origin Country [105]
Tesla	Tesla Inc.	America
Lexus	Toyota Motor Corp.	Japan
Infiniti	Renault-Nissan-Mitsubishi Alliance	Japan
BMW	BMW Group	Germany
Mercedes Benz	Daimler AG	Germany
Audi	Volkswagen AG	Germany

This chapter examines ADAS and autonomous driving functions, emphasising the critical need for the automotive industry and regulators to establish clear standards. These standards will ensure consistency across manufacturers, which can accelerate the design and development of AVs, build public trust, and increase adoption rates. The methodologies and data sources for this analysis are detailed in the following sections, highlighting our reliance on leading car manufacturers' latest user manuals and specifications to provide a robust basis for our conclusions.

The remaining of this chapter is structured as follows. Section 3.2 elaborates details on the research approaches used in conducting the survey, followed by an in-depth analysis of the findings. Factors that are limiting the broad adoption of ADAS functions are identified and further discussed in Section 3.3. Based on the findings and analyses, recommendations for stakeholders and concluding remarks are provided in Section 3.4.

3.2. Methodology and Analysis of Results

This study aims to elaborate on the importance of standardising the naming convention of the technologies and informing drivers on the operating conditions of various ADAS functions equipped in modern vehicles. The outcomes of this study will help stakeholders in the automotive industry in developing guidelines and frameworks to govern the naming and information disclosure of AI-based autonomous driving functions in the future. To understand the problem, we went through the user manuals systematically and conducted critical analyses of ADAS functions found in modern sedans

from different automotive brands, which is summarised in Table 3.3. The analytical processes are further elaborated as follows.

- i. The process begins with searching for ADAS functions in each brand's user manuals with keywords mentioned in the American Automobile Association (AAA) report [13].
- ii. Due to different marketing naming conventions and usages of technical terminologies, sections around the keywords in the manuals were studied manually to categorise the functions' natures.
- iii. The Australian New Car Assessment Program (ANCAP) and the Traffic Injury Research Foundation have defined active and passive safety systems that are central to understanding the implementation of ADAS technologies. Active safety systems, also known as active safety features, are engineered to prevent potential accidents [106, 107]. These include technologies such as lane-keeping assist, forward collision warning, and adaptive cruise control. Conversely, passive safety features are designed to protect passengers from further injury in the event of an accident, examples of which include seat belts, airbags, and crumple zones [106, 107]. Subsequently, the ADAS functions have been systematically categorised into active or passive functions based on these definitions [106, 107]. To maintain the generality of this study, only common functions appearing in reports of industry regulatory bodies, namely the National (US) Highway Traffic Safety Administration, AAA, and ANCAP, are chosen [13, 106, 108].
- iv. ADAS functions that directly act on behalf of the driver on the road and assist the driver in making complex driving decisions are retained for analysis, and the rest of the functions are discarded.
- v. Afterwards, ADAS functions with electronic controllers are retained for comparisons and analyses, and the rest of the functions are discarded.

Operational conditions and limitations of the selected ADAS functions among all the brands under this study have then been collected for more in-depth comparisons. Via the exhaustive search, we found that there is no consistency between manufacturers in naming their ADASA functions. There are functions that have the same purposes but are named differently, and in some cases, ADAS function's names are very similar, but their functions are different [29]. The selection process of ADAS functions for this study is shown in Figure 3.1, and the results are presented in Table 3.3.

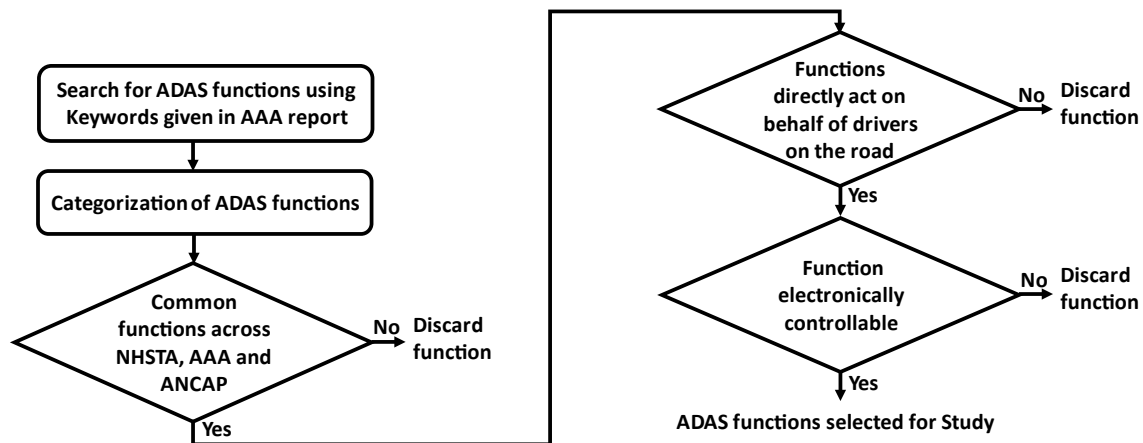


Figure 3.1: Selection Process ADAS function for study

- i. It is observed that terminologies used to define and describe the same or similar ADAS functions vary across the selected car models. Some of them have been replaced by trademarks or product names that do not directly reflect their fundamental functions in intuitive ways. The finding concurs with that in [13], as discussed in Chapters 1 and 2, which stated that forty unique names were used by different manufacturers to label their Collision Avoidance (CA) systems. Details on the unique names used by the manufacturer to describe the ADAS function can be found in [13].
- ii. Manufacturers tend to combine multiple safety features into ADAS packages and provide buyers with high-level product names. For example, BMW Intelligent safety includes eight different ADAS functions [109] Lexus safety system +A comes with six ADAS functions [110] Nissan's Intelligent safety shields include nine ADAS functions [111], and Tesla AP comes with thirteen ADAS functions [112]. Further details are presented in Table 3.4.
- iii. Another observation that wasn't covered in previous surveys is that some ADAS functions' operational conditions or limitations vary across the selected models, as shown in Table 3.3. It is important for drivers to acknowledge and clearly understand the limitations and operational conditions of each ADAS function on their vehicles. Such discrepancies can introduce confusion for drivers. From Table 3.3, it is observed that the operating conditions of different ADAS functions vary even within the same model. This can create ambiguity and cause misjudgement for drivers, especially in emergencies. A typical example is ACC which is a popular function in modern vehicles. However, the minimum

and maximum speed thresholds for it to be functional are significantly different from model to model, which could be one of the root causes of the finding in [27], which reported only 26.1% of users claimed they use adaptive cruise control regularly.

- iv. Control procedures vary significantly across functions and models, including pressing a button once, holding a button for a specific amount of time, or changing the settings via the dashboard's interface. Warning signs and the way that they are given, including constant indicators, flashing, chimp sounds, and vibrations, are also very different. All these can cause disturbances to drivers.
- v. Conditional statements such as non-favourable driving conditions, poor visibility, narrow lanes, worn lane marking, light interferences, and different levels of sensor obstructions or misalignment introduce uncertainties and can lower the driver's confidence in utilising these functions. Key system limitations are illustrated in Figure 3.2.

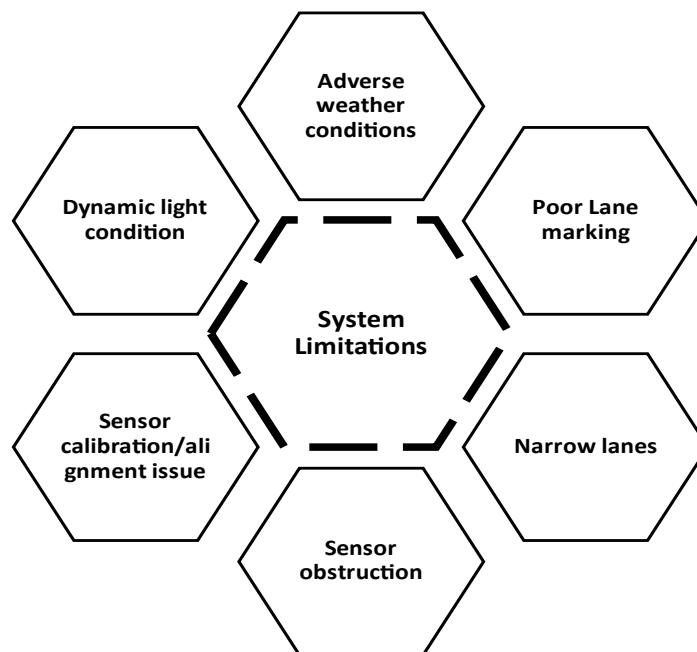


Figure 3.2: ADAS functions limitations discussed in the user manual

- vi. According to ANCAP, active ADAS functions can effectively avoid fatal crashes. Active functions such as LKA, blind spot intervention, ACC, etc., all intervene and make corrective steering/braking manoeuvres under emergencies. However, the descriptions of the car's behaviour, such as the amount of steering it provides when performing those rectification

actions, are vague and not quantifiable. Currently, there is no suggested way for drivers to experience them for training purposes under safe conditions.

- vii. It is also observed that there are no clear guidelines on the calibration and maintenance of ADAS functions.

Table 3.3: Comparison of ADAS functions across different selected care models. The corresponding operating conditions/limitations are stated inside square brackets.

	BMW 7 Series [109]	Mercedes S Class [113]	Audi A8 [114]	Tesla S Series [112]	Infiniti Q50 [115]	Lexus Ls500 [110]
Collision Avoidance	Front Collision Mitigation [Above 5km/h]	Active Brake Assist [Above 7km/h]	Audi Pre-Sense [Above 30km/h]	Collision Avoidance Assist [10-150 km/h]	Predictive Forward Collision Warning [Above 5km/h]	Pre-Collision System [5-180km/h]
Adaptive Cruise Control	Active Cruise Control with Stop and Go Function [30-180km/h]	Active Distance Assist DISTRONIC [20-210km/h]	Adaptive Cruise Assist [above 30km/h]	Traffic Aware Cruise Control [0*-150km/h] *when behind another vehicle	Intelligent Cruise Control [32-144km/h]	Dynamic Radar Cruise Control (vehicle to vehicle distance control) [Above 30km/h]
Cruise Control	Cruise Control [30-180km/h]	Cruise Control [20-250km/h]	Cruise Control [Above 20km/h]	Traffic Aware Cruise Control [30-150km/h]	Cruise Control [40-144km/h]	Dynamic Radar Cruise Control (constant speed control) [Above 30km/h]
Blind Spot Assist	Side Collision Mitigation [5-210km/h]	Active Blind Spot Assist [30-200km/h]	Side Assist [Above 10km/h]	Blind spot collision warning chime [12-140 km/h]	Blind spot Intervention Above 60km/h]	Blind Spot Monitor (BSM) [Above 16km/h]

Lane Keeping Assist	Lane Departure Warning [Country specific - 210km/h]	Active Lane Keeping Assist [60-200km/h]	Lane Departure Warning [65-250km/h]	Lane Departure Avoidance [64-145km/h]	Lane Departure Prevention [Above 70km/h]	Lane Tracing Assist (LTA) [Above 50km/h]
Automatic High Beam	High Beam Assistant [Activation speed not reported]	Adaptive High Beam Assist [Above 30km/h]	High Beam Assistant [Activation speed not reported]	High Beam Head Lights [Activation speed not reported]	High Beam Assist [Above 35km/h]	Automatic High beam [Above 34km/h]
Adaptive Front Lighting	Adaptive Light Function [Activation speed not reported]	Active Headlamps Function [Activation speed not reported]	Adaptive Light [Activation speed not reported]	Adaptive Front Lighting System (AFS) [Activation speed not reported]	Adaptive Front Lighting System (AFS) [Above 5km/h]	Adaptive Front Lighting System (AFS) [Above 10km/h]

Table 3.4: Car Brands ADAS Packages and available function

Car Brand Name	ADAS Package Name	Number of safety functions available
BMW [109]	Intelligent Safety	8
Mercedes [116]	Intelligent Drive	8
Audi [117]	Audi Pre sense system	9
TESLA [112]	Auto Pilot	13
Nissan/Infinity [111]	Infinity Safety Shield	9
Toyota/Lexus [110]	Lexus Safety System +A	6

3.3. Discussion

3.3.1. Different Naming Conventions used by Automakers:

It is evident from Table 3.3 that manufacturers use very different terminologies to describe their ADAS functions. Very often, car brands bundle multiple safety functions into one package and present their customers with a generic product name. According to [118], two leading car manufacturers use autopilot or pro-pilot assists, and 40% of drivers misinterpreted that the above systems have autonomous driving capabilities. Table 3.4 illustrates ADAS package names used by the selected car

models in this study, together with the number of safety functions they cover. Currently, there is no consensus or agreement between automakers and regulators on standard names to reflect ADAS functions, which makes it hard for motorists to discern, compare, or even use them. As recommended in [13], the automotive industry needs to come up with standard terminologies for their ADAS features. Regulators need to develop rules and standards for automakers and their suppliers to follow when disclosing those essential technical details.

One factor contributing to the low adoption and utilisation rates of ADAS functions by drivers is the lack of intuitive naming conventions [29]. The lack of uniformity in naming ADAS functions can add confusion and ambiguity for drivers while using those functions in a dynamic driving environment. It also becomes difficult for buyers to compare the ADAS functions available in different vehicles. Automotive industry regulators across the globe should come up with general rules for naming AI/ADAS functions across the industry. Based on the regulations of different local authorities, manufacturers should further provide customers with proper terminology mapping. Consumers should be aware of the technology their cars have been using to make well-informed buying decisions.

3.3.2. Different Operating Conditions and Procedures:

Table 3.3 implies that operating conditions and parameters of ADAS functions vary across selected car models. Inadequate knowledge and lack of clarity on the system's functional requirements can lead to severe road safety issues. Human intervention is always involved for AVs of SAE Level 4 or lower. Therefore, automakers must develop uniform operating conditions and procedures so drivers can use those functions confidently, as variations in operating conditions can confuse the driver when using the ADAS function in a dynamic driving environment. From Table 3.3, it is observed that the operational speeds of some ADAS functions can vary significantly across brands. That makes it extremely hard for human drivers to understand and remember the capability and limitations of the ADAS functions in their cars, especially for novice AV drivers. If a driver of a highly automated machine does not have a clear and accurate understanding of the capabilities and limitations of each of the ADAS functions, he/she can make wrong decisions and may wrongly rely on the technology when it is unsafe to do so. If the operating procedures of the ADAS functions are too complex, the driver may not be confident in activating and operating those ADAS functions, which leads to a low utilisation rate.

It is also essential for automotive regulators and manufacturers to design simple and consistent procedures for drivers to activate/deactivate ADAS functions. The simplicity of the procedures is crucial as drivers are often required to follow or execute them while driving or during emergencies. Automakers should jointly design common and intuitive visualisation frameworks (warning notifications, symbols, colour and sequencing order of visual and audio indicators, etc.) to alert drivers of potential hazards. Research shows that, on average, a human driver takes 1.5 seconds to identify a hazard and make the necessary manoeuvring adjustments to avoid a potential crash [119]. A driver assistance system can take hundreds of milliseconds to alert the driver of potential hazards. During that time, if the driver is engaged in non-driving tasks such as accessing the in-car infotainment system, it could add hundreds of milliseconds [119]. The situation can be more severe for AVs as their drivers are not expected to engage in driving except under extreme conditions. It is worrying that AVs may not provide enough time for their drivers to react in hazardous situations. Furthermore, as AV owners could have fewer hands-on on-road experiences due to their reliance on self-driving functions, it can be expected that AV owners will take an even longer time to react. If there is no well-defined and consistent approach across the manufacturers on controlling those ADAS and self-driving functions in case of an emergency, the aforementioned time delays will increase the probability of a crash.

An example that resonates with the above argument is the tragedy of British Midland Flight 92 on January 8th, 1989. After its take-off, its crew experienced vibration and smoke on the flight deck. Due to a lack of knowledge about the design of the new aircraft, its first officer couldn't assimilate the electronic instrument readings correctly and recommended the pilot to shut down the wrong engine, which led to a crash [86]. According to the investigation report, the lack of understanding about the new design of the aircraft and the non-intuitive electronic indicators are two of the major causes of this fatal disaster [86]. This event highlighted the importance of training and understanding the behaviour of the manoeuvring system of a vehicle/vessel under emergencies. According to the Australian Civil Aviation Safety Authority, to obtain an air transport pilot licence, pilots are expected to complete at least 1500 flying hours [26]. However, owners of vehicles with ADAS functions or AVs nowadays are not required to go through an equivalent extensive training, which means automakers need to ensure that their control interfaces are simple, intuitive, and standardised across the industry. Automotive industry experts have a consensus that there should be training provided to AV users for them to obtain the optimal benefit from the technology [120]. Automakers and their

resellers should also ensure the end-users are well-informed and received adequate and regular training on the functionality and operations of those ADAS and self-driving functions.

In summary, the lack of consistency in operating speed and procedures can lead to misunderstanding and misjudgement of the drivers. Manufacturers should describe the operating conditions of the ADAS functions in quantifiable terms so that users can understand the level of automation and the operating conditions of each ADAS function clearly and accurately. A consensus should be developed across manufacturers on obtaining baseline operating conditions of different ADAS functions so buyers are well-informed about what provisions to expect in a dynamic driving environment and potential emergencies. A standard across automakers on control procedures of various ADAS and self-driving functions is also needed. There should be a consistent design philosophy on warning notifications, instrument cluster display, button holding time, sequencing order of visual and audio indicators, and dashboard. To facilitate that, regulatory authorities should initiate a study on the effectiveness of different control procedures and warning messages. Based on the research outcomes, automakers should produce a common design philosophy, including but not limited to warning notifications, instrument cluster display, button holding times, and operating speed of various ADAS functions.

3.3.3. ADAS Limitations and Maintenance Issues:

Automakers alert that ADAS functions may not work in some situations or may work with limited capacity. However, terminologies used by vehicle manufacturers to describe the limitations are vague. For example, adverse weather conditions such as rain, snow, fog, wind, glare light, or during winter, lane markings can be covered by snow, heavy rain, etc. [121]. Similarly, lane marking can be ambiguous for AVs to detect in glare light [121]. Another issue is related to road infrastructure, i.e. narrow lanes, poor lane marking, etc. Most ADAS functions rely on lane markings and other features of road infrastructures; however, without a clear definition of their wear and tear conditions, it is hard to interpret when ADAS would fail and require human interventions. For weather, lighting, and road conditions, automakers need to provide a scientific definition of the above situations and design quantifiable measures for each of them so consumers can make comparisons and have a better understanding of their cars.

An example that elaborates the importance of driver/pilot understanding of behaviours of active control systems and sensor limitations on board is the flight incident of Air France 447. The incident happened on 1st June 2009, when the computer deactivated the autopilot system because the airspeed sensors called pitot tubes were blocked by ice [122]. Unfortunately, the pilots did not assimilate the problem and pulled back the control stick, which forced the plane into a steep climb and caused it to stall, and the plane started free-falling from the sky [122]. This catastrophe highlights three areas that require industry expert's attention. The first one is the importance of the autonomous system operator's understanding of sensor limitations and behaviour. Sensors must be regularly cleaned and properly calibrated. However, consumers are not trained for that, so automakers and their resellers need to educate the consumer and remind them about that. The cleaning and calibration process should be simple. Automakers may need to redesign their sensors or adopt more advanced technologies. The second point is the importance of letting the user know the behaviours of the assistive and active control system onboard. Currently, users are relying on the information available through the user manual, the internet, or the trial and error method. Automakers should use quantifiable measures to describe the system's behaviours under emergencies. For example, how much steering is provided and for how long it takes to keep the car in a lane. How hard will it be to brake when brake assist is activated? Automakers should also design ways to demonstrate that behaviour to users under safe conditions, including videos. Thirdly, it is observed from the AF447 incident that unanticipated takeover requests are very difficult for humans to handle. Even highly qualified, well-trained pilots can panic and make wrong decisions [122]. ADAS and AVs should provide enough time for human drivers to focus on the road again before transferring the control. These systems may also need mechanisms for measuring drivers' readiness in overtaking.

Terminologies used by the automakers to describe the limitations of the system are imprecise and cloudy, such as poor weather conditions, narrow lane marking, etc. Similarly, descriptions about the behaviours of ADAS functions in making corrective steering/breaking manoeuvre are also ambiguous. Another issue is that ADAS functions do not have a clear calibration process or maintenance guidelines. Manufacturers should formulate scientific definitions of the above situations and design quantifiable measures for each so consumers can make enhanced comparisons and better understand their cars. Automakers should also design ADAS with uniform and quantifiable corrective manoeuvring behaviours so drivers can coordinate with the systems during emergencies.

Nevertheless, to ensure ADAS operate at their peak performance, manufacturers should also provide clear and simple instructions on maintaining and calibrating the ADAS for users.

Factors discussed in sections 4.1, 4.2, and 4.3 are limiting the prevalence of ADAS functions. There are functions that are available since the mid-20th century; however, they are not widely used by drivers [67]. The study in [29] shows that some ADAS functions have low utilisation rates, as shown in Table 3.5. The table below indicates that automakers and automotive industry regulators have a role to play in ensuring that uniformity in naming conventions, operating conditions, operational procedures, and system limitations of ADAS can be achieved. It is expected that by implementing the aforementioned recommendations, the driver's understanding level of ADAS functions can be increased, which can help improve the adoption rate of ADAS functions.

Table 3.5: ADAS function average regular user

ADAS Function Name	Function available since [67]	Regular user [29]
Cruise control	1960	33.3%
Adaptive cruise control	1998	26.1%
Lane keeping Assist	2001	9.8%

3.4. Chapter Summary

This chapter addresses the critical necessity for standardising ADAS's nomenclature, designs, and operational procedures as the automotive industry advances towards full vehicle autonomy. It highlighted the challenges stemming from varied and inconsistent ADAS terminology and operational methods across different car manufacturers, which can confuse drivers, lead to underutilisation, and risk potential misuse of these systems. The analysis utilised findings from a systematic review of user manuals from various brands, uncovering significant disparities in how ADAS features are named and operated. Such inconsistency can undermine the effectiveness of ADAS technologies in enhancing road safety, which is crucial given their potential to significantly reduce accidents caused by human error.

The chapter underscored the necessity for an industry-wide consensus on ADAS terminology and operational guidelines, as a means to substantially elevate the safety and performance of these technologies. This standardisation would promote more transparent communication and understanding, boosting public trust and adoption rates of these technologies. It called for

collaboration among stakeholders, including transport industry leaders, AI experts, and regulators, to develop and implement regulatory frameworks that govern the evolution of vehicle automation. Moreover, the chapter outlined the selection criteria for vehicle brands included in the study, ensuring a diverse representation of geographical origins and technological advancements. This rigorous approach supports the chapter's findings and recommendations for establishing clear, intuitive, and uniform standards across the automotive industry. By addressing these standardisation needs, this chapter concludes that the automotive sector will be better equipped to navigate the complexities of ADAS and autonomous driving technologies, leading to safer and more reliable vehicle automation.

Chapter 4: Enhancing Driver Performance in Autonomous Systems Through Training

This chapter examines the critical role of training in enhancing drivers' performance within the rapidly evolving landscape of ADAS and AV. As these technologies advance, the interaction between human drivers and automated systems becomes a pivotal concern for road safety. This study explicitly explores how different training sessions impact novice and experienced drivers regarding their ability to operate AVs and effectively utilise ADAS features. Utilising a simulation-based approach, the research involved a diverse cohort of participants varying in age, gender, driving experience, and frequency of ADAS usage. These participants were subjected to multiple driving scenarios where they interacted with a virtual subject vehicle under varying conditions of ADAS functionality. Key performance metrics such as accuracy, reaction time, and vehicle control were meticulously recorded and analysed post-training.

The findings underscore significant improvements in all measured aspects of driving performance post-training, illustrating the essential value of structured training programs. The chapter explores the implications of these results for stakeholders such as policymakers, vehicle manufacturers, and driver education providers, suggesting enhancements in driver training curricula. Additionally, it points towards future research avenues, including the exploration of AI-assisted coaching and real-time feedback systems, to further refine the training processes for AV and ADAS interactions.

4.1. Introduction

Each year, over twenty million road accidents occur globally, with thousands of fatalities in Australia alone due to various factors, primarily centred around human negligence, such as speeding, distracted driving, intoxicated driving, and driver fatigue [5]. According to the National Road Safety Partnership Program (NRSPP) in Australia, human factors contribute to more than 90% of accidents,

with only 7% resulting from mechanical failure or environmental factors [123]. The proper utilisation of AV technology has the potential to enhance the safety of drivers and other road users. It is estimated that a higher adoption rate of ADAS in on-road vehicles could help reduce crashes by 90% [8].

As discussed in Chapter 2, training for ADAS and AV technologies presents distinct challenges, primarily due to the diversity of interface layouts across different automakers and the complexity of the systems involved. Customised training strategies are crucial for effective operation and safety, emphasising the need for training that encompasses procedural operations such as ACC and LKA and higher cognitive skills. These skills, including situational awareness and risk assessment, are essential for navigating potential hazards effectively [27, 78]. The acceptance of AVs and the effective utilisation of ADAS functionalities have attracted significant research interest ([124], reflecting the growing recognition of their potential to impact road safety significantly. This attention is crucial as previous research has indicated that one significant barrier to ADAS adoption is the lack of understanding of their functions and limitations [19], reinforcing the need for comprehensive educational strategies. Current training methodologies, often reliant on owner's manuals, have been identified as inadequate [27]. This inadequacy highlights the critical need for more robust training programs comprehensively designed to enhance procedural and higher-order cognitive abilities, as established in Chapter 2.

Extensive research in the aviation, maritime, and medical sectors supports the idea that continuous training can improve end-user's real-world performance [79]. It is widely recognised that pilots and other crew members need to periodically refresh their training skills, with the frequency of training dependent on factors such as the type of aircraft and accumulated flight hours [80, 125]. Similarly, in the maritime industry, crew members must undergo comprehensive training and regularly update their skills, as evidenced by the requirement to conduct weekly drills for the operation of watertight doors, valves, and closing mechanisms of scuppers [126]. Training is crucial for ensuring the safe operation of technology, particularly when changes are made to the interface of an instrument [19]. Consequently, ongoing training remains essential across various industries for maintaining proficiency and adapting to evolving technological demands. Training is paramount when operating new technologies, particularly complex systems like aeroplanes and ships, and the same applies to vehicles equipped with ADAS functions [19]. As ADAS systems can differ significantly between automakers, it is essential for end-users to receive appropriate training for their safe use [19].

Interface layout differences among automakers can further complicate system operation, underscoring the need for training [19].

This chapter aims to investigate the influence of training on participants' abilities to interact with modern vehicles equipped with ADAS functions and prepare them for operating AVs in the future. We conducted experiments to measure the impact of training on participants' performance in terms of accuracy, reaction time in interacting with ADAS functions, and vehicle control when interacting with them. The primary objective of this study is to ascertain whether end-users using ADAS and autonomous driving features require rigorous training comparable to that of aircraft pilots and ship captains to operate these functions safely. Additionally, this study aims to explore the necessity of multiple training sessions for drivers (or vehicle operators) to develop their procedural and cognitive skills and understand the effect of repeated sessions on their performance. Furthermore, the study investigates whether experienced drivers require less training than novice drivers to utilise ADAS and AV functions effectively and whether the regular use of these functions diminishes the need for repeated training. However, it is important to clarify that this paper does not cover the regulatory and licensing aspects of vehicles equipped with ADAS functions or AVs. Additionally, as the study was conducted in a simulated environment, it may not fully encapsulate real-life driving conditions. The findings may differ when applied to real-world scenarios, warranting further investigation using practical, on-road testing.

This chapter is organised as follows: Section 4.2 presents the methodology, experimental setup, and driving environment. Section 4.3 describes the recruitment process and the composition of the participants. Section 4.4 analyses the participants' accuracy and response delays, considering their driving experience and frequency of ADAS function usage. In the same section, we further study the vehicle's lateral position relative to the centre of the road and use it to evaluate the performance of the participants. Section 4.5 discusses the importance of training for better accuracy, reaction time, and vehicle control. Based on the findings and analyses, recommendations for stakeholders and concluding remarks are provided in Section 4.6.

4.2. Methodology

4.1.1 Experiment Setup

The experimental setup employed a York driving simulator in conjunction with a Logitech G27 racing wheel, which included pedals and a shifter. Various ADAS functions (shown in Table 4.1) were mapped to buttons located on the steering wheel and the shifter module. The experiment involved a subject vehicle (SV) manoeuvre within a 3D virtual environment, either autonomously or controlled by participants with ADAS functions enabled or disabled. The SV was configured with an automatic transmission, allowing the panel on the shifter module to be exclusively dedicated to activating and deactivating ADAS functions while the shifter lever was disabled. We meticulously designed the experiment to emulate an authentic and immersive driving experience for the participants, thereby ensuring a high degree of ecological validity in the observed outcomes. The experimental setup is illustrated in Figures 4.1 and 4.2. In Figure 4.1, components "a" to "c" indicate the steering wheel, driving seat, and pedals, respectively.

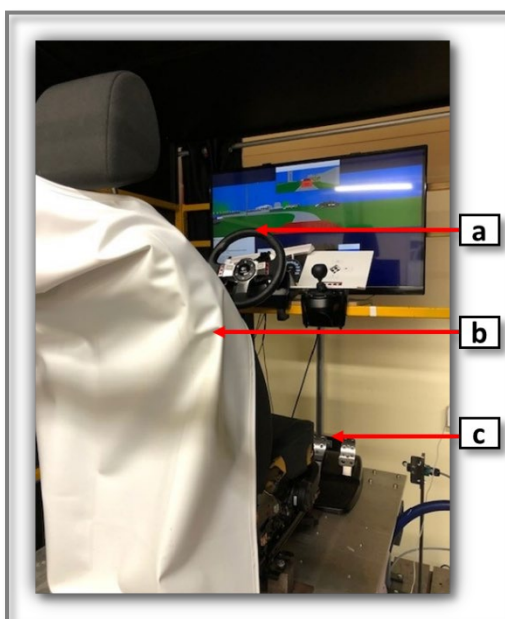


Figure 4.1: Experiment setup [a: steering wheel, b: driving seat, c: pedals]

Figure 4.2 shows the locations of components 'd' to 'f' on the steering wheel, illustrating the driving environment, ADAS, and AV functions. It also details the locations of the ADAS functions on the shifter module.



Figure 4.2: Experiment setup [d: driving environment, e: ADAS buttons location on steering wheel, f: ADAS buttons location on shifter module]

4.1.2 Driving Scenario and Environment

The simulator interface is depicted in Figure 4.3, with the red box representing the bonnet of the SV. The dashboard below features a speedometer and indicators for the states of the ADAS functions, which are illuminated in green when activated. The 3D virtual environment incorporates several key features commonly found in typical road setups, such as different traffic densities, streetlights, road signs, pedestrians, various speed limit zones, buildings, and vegetation. These elements enhance the driver's situational awareness and understanding of their surroundings [127], inside the simulated space. Figure 4.4 presents a bird's-eye view of the driving scenario, with the red circle indicating the SV's starting location. The lower-speed (50 km/h) and higher-speed (100 km/h) loops are marked with red and blue arrows, respectively. These different speed limits simulate transitions between urban and highway scenarios, providing participants with different driving scenarios.

During an experiment, participants were instructed to begin in the lower-speed loop, cross the intersection, enter the higher-speed loop, cross the intersection again, and return to the lower-speed loop. Multiple triggers (T1 to T5) were implemented along the route to initiate different events as the SV passed by, as shown in Figure 4.4. Table 4.1 lists the corresponding instructions for these triggers. When the SV passes a trigger, an audio instruction from Table 4.1 is played, directing the participant to perform an action. Among the five actions, only CC requires a sequence of button presses, while the others involve a single button press. In this paper, data on the steering wheel, acceleration, brake, event triggering time, drivers' response time to events, and vehicle lateral position and movement were selected for further study. From the collected data, we measured the

accuracies (in %) of drivers in interacting with the correct ADAS functions, the corresponding response delay (in seconds), and vehicle lateral position from the centre of the lane (in meters).

Table 4.1: Instruction for each Trigger

Trigger No	Instruction
T1	Turn on the “auto-pilot” (autonomous function)
T2	Turn off the “auto-pilot” (autonomous function)
T3	Turn on the lane-keeping assist function
T4	Turn on the collision avoidance function
T5	Turn on the cruise control function

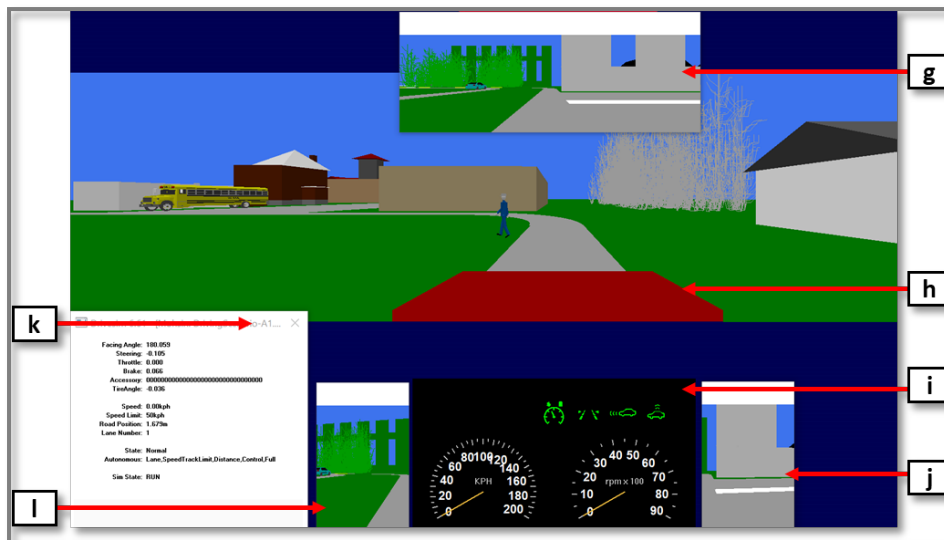
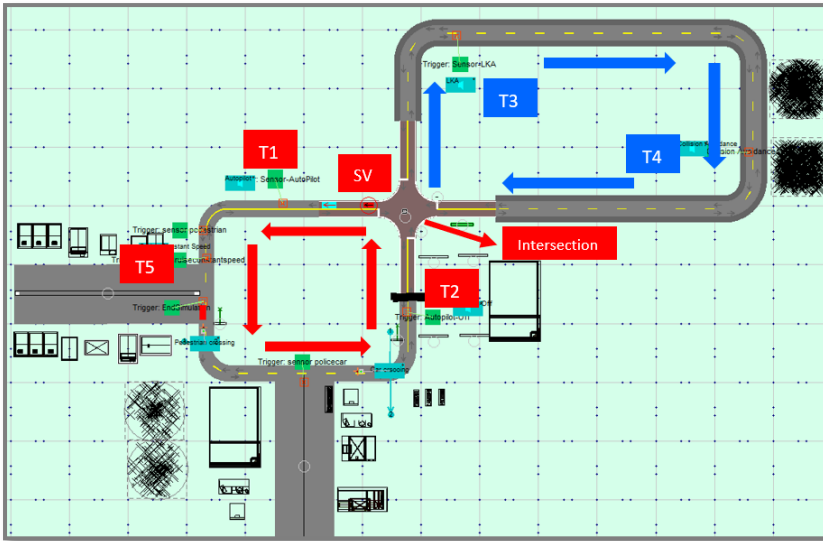


Figure 4.3: A snapshot of the simulator interface that shows the bonnet of the SV [g: Rear mirror view, h: front of the SV, i: Dashboard, j: right side mirror view, k: SV parameter, l: left side mirror view]



4.3. Recruitment of the Participants

This study aimed to investigate a heterogeneous sample of RMIT University students and staff, encompassing various ages and genders. The recruitment process was conducted through a combination of digital and traditional methods, utilising the university's online platform complemented by paper-based advertisements disseminated across the RMIT Bundoora campus. The final participant pool included 43 adult individuals with driving experience ranging from one to eight years or above. Eligibility criteria stipulated that all participants must possess a valid driving licence. A close-to-balanced gender representation was achieved within the group, comprising 25 males and 18 females. To mitigate potential bias, both staff and student participants were selected from a diverse array of academic disciplines, ensuring a broad spectrum of educational backgrounds. Before initiating the experiment, participants were thoroughly informed about the study's purpose and procedures, and their informed consent was duly obtained.

The experimental protocol underwent rigorous review and received approval from the RMIT University Human Research Ethics Committee (Approval Number: EC 25022), thereby adhering to the requisite ethical standards and guidelines for academic research.

4.3.1. Participant's Registration and Briefing Session (1st trial/session):

Upon arrival for the first trial, participants completed the registration process and were subsequently directed to watch an introductory video about the experiment. This video, approximately ten minutes in length, provided a comprehensive overview of the study's objectives, hardware setup, virtual driving environment, driving route, and the operation of select ADAS functions. Additionally, the video detailed the participants' expected actions and required responses while driving in the simulated environment and encountering specific triggers. Following the viewing of the introductory video, participants were invited to drive the SV for the first time in Trial Number 1. In order to simulate the experience of purchasing a new vehicle, the video demonstrated only three of the five ADAS functions. This approach was informed by the observation that car dealers typically showcase a limited number of key functions during demonstrations due to time constraints and legal limitations. A meticulous approach was employed in designing the introductory video to ensure an accurate explanation of the experiment setup and a professional demonstration of the ADAS functions. To maintain consistency across the study and ensure that all participants received the same level of information, we utilised video recordings as a training and demonstration medium. This approach was also supported by [88], who suggests that video-based training is an effective way to provide training.

4.3.2. Repeated Sessions (2nd and 3rd trial/sessions):

After the first trial, participants were provided with a user manual for the driving simulator, which was designed to replicate a real vehicle owner's manual. The manual comprised three chapters, with chapter one offering an overview of the driving simulator's interface, layout, and operations. Chapter two of the manual provides detailed descriptions of the functionality and activation/deactivation processes for each ADAS and AV function of the driving simulator, while chapter three outlines the boundaries and limitations of each ADAS function. For the second trial, participants returned after a gap of one, three, or five days, depending on their availability, as determined by [128]. The third visit provided participants with the option of completing the session on the same day as their second visit (with at least a 15-minute gap) or after a one-day or seven-day gap [128]. To prevent rote memorisation or negative effects from repetition learning, the order and location of triggers in the virtual environment were rearranged for each subsequent session.

4.4. Results and Analysis

This study aimed to explore the importance of training for end-users of ADAS and autonomous driving functions. Each participant was required to complete three experimental sessions, during which they drove an SV equipped with ADAS functions and self-driving features. The data were analysed against their real-life driving experience and frequency of use of ADAS functions. Participant performance was assessed in three ways. Firstly, end-user accuracy was measured as a percentage of correct button presses in response to the system's instructions. Secondly, we measured response delays in seconds to system requests for the activation/deactivation of an ADAS function. Finally, we analysed the Root Mean Square Error (RMSE) value, measured in meters, of the vehicle's centre point to the centre of the lane to contextualise the severity of the serpentine driving situation while the users were activating/deactivating the ADAS functions.

4.4.1. Analysis Based on the Driving Experience:

The analysis suggests that participants with more driving experience performed better in terms of accuracy and learning pace than those with less driving experience. However, all groups of participants showed improvement after the training sessions, indicating that additional training is essential, even for experienced drivers.

The participants were divided into three groups based on their driving experience, namely Group-1 (1 to 3 years of driving experience), Group-2 (4 to 7 years of driving experience), and Group-3 (8+ years of driving experience). Table 4.2 shows that all groups performed well on the ADAS and AV functions introduced in the introductory video. However, after examining the user manual, we noticed that the results varied between experienced and non-experienced drivers, particularly for function-4 (CA) and function-5 (CC), which were intentionally not displayed in the video. The goal of this activity was to mimic the car dealer's explanation process about the new features of the car. As we are aware that, for different reasons and limitations, the car dealer may only show some of the functions to the buyers.

Function-4 (CA) posed challenges for the participants, particularly for those with a short driving experience. In the case of function-4 (CA), participants with less driving experience (1 to 3 years) showed a gradual improvement in their performances from 0% on their 1st visit to 56% on their 2nd visit and then to 100% on their 3rd visit. Participants with a greater driving experience (4 to 7 years

and 8+ years) showed better performances, with 77% and 100% accuracy, respectively, in their 2nd and 3rd visits. The results suggest that driving experience can help drivers learn and locate buttons faster, but it cannot replace the importance of extra training.

Table 4.2: Participant's Response accuracy w.r.t their driving experience

Groups-Division w.r.t driving experience	No of participants in each group	Trial/Visit No	AP-on response accuracy in %	AP-off response accuracy in %	LKA response accuracy in %	CA response accuracy in %	CC response accuracy in %
Group-1 (1-3 years)	16	1st	100	100	62	0	0
	16	2nd	100	100	81	56	50
	16	3rd	100	100	100	100	100
Group-2 (4-7 years)	13	1st	100	100	69	7	0
	13	2nd	100	100	84	77	56
	13	3rd	100	100	100	100	100
Group-3 (Above 8 years)	14	1st	100	100	78	0	0
	14	2nd	100	100	100	100	64
	14	3rd	100	100	100	100	100

Table 4.3: Participant's Response accuracy w.r.t their ADAS functions frequencies of use

Groups-division w.r.t ADAS function frequency of use	No of participants in each group	Visit/Trial No	AP-on response accuracy in %	AP-off response accuracy in %	LKA response accuracy in %	CA response accuracy in %	CC response accuracy in %
Group-4 Never used	13	1st	100	100	57	7	0
	13	2nd	100	100	71	53	46
	13	3rd	100	100	100	100	100
Group-5 Intermittent user	16	1st	100	100	75	0	0
	16	2nd	100	100	87	62	56
	16	3rd	100	100	100	100	100
Group-6 Regular user	14	1st	100	100	85	0	0
	14	2nd	100	100	100	100	71
	14	3rd	100	100	100	100	100

In the case of function-5 (CC), subjects were expected to press two buttons in sequence to activate the CC function, mimicking the activation process of CC in real life. It was noticed that the activation process of CC varies from manufacturer to manufacturer, with some requiring drivers to press the

same button twice while others require pressing two different buttons. The results from Table 4.2 show that the highest performances were recorded on the third visit for all three groups, indicating the importance of training even for experienced drivers. These findings are consistent with previous studies, which have reported significant improvements after two training sessions [129].

Overall, the analysis suggests that training and experience are both important factors in learning and using ADAS functions effectively. While driving experience can help drivers locate buttons faster, additional training is necessary to understand the specific implementation of functions in different car models.

4.4.2. Analysis Based on the Frequency of ADAS Function Usage:

Table 4.3 illustrates the correlation between participants' proficiency in activating ADAS functions and the frequency of use during driving. Among participants who reported never utilising ADAS functions (Group-4) while driving, merely 57% accurately activated function-3 on their initial attempt, even after being exposed to it in the instructional video. In comparison, participants who employed ADAS functions intermittently (Group-5) or regularly (Group-6) demonstrated heightened accuracy rates of 75% and 85%, respectively. Notably, individuals who utilised LKA in real-life driving outperformed those who had never engaged in ADAS functions while driving in ADAS activation tasks. For function-4 CA, accuracy rates during the second visit were 53%, 62%, and 100% for the never-used, intermittent, and regular user groups, respectively. These findings imply that consistent utilisation of ADAS functions may reduce the need for frequent refresher training when compared to non-users.

To activate function-5 CC, participants were required to sequentially press two buttons. In the second visit, accuracy rates for the never-used, intermittent, and regular user groups were 46%, 56%, and 71%, respectively. However, during the third visit, all groups attained 100% accuracy. Furthermore, continuous usage of ADAS functions is expected to foster long-term retention of learned skills, reducing the need for frequent refresher training. This suggests that regular practice helps to consolidate knowledge, enabling it to become ingrained in the driver's memory for more efficient recall and application. This observation concurs with the study conducted by [130].

In addition, our findings reinforce the argument in the "Analysis Based on Driving Experience" section, indicating that the most significant improvement can be observed after two training sessions. These findings are consistent with the research conducted by [129].

4.4.3. Analysis of Participant's Delay in Reaction Time

4.4.3.1. Analysis of reaction time for function demonstrated in an introductory video

An examination of Figure 4.5, which illustrates the Box plot of the AP-On function, reveals that during the participants' first visits, the median time for activating the AP function was 3.17 seconds, with response times ranging between 1.60 and 5.27 seconds. Notably, the median response time decreased to 2.54 seconds during the second visit and further decreased to 2.30 seconds during the third visit. Figure 4.5 clearly shows that the participants' reaction times were more closely distributed around the median in the final trial, suggesting participants increased familiarity with the AP-On function.

A similar trend was observed in Figure 4.6, which displays the Box plot of the AP-Off function. In the participants' third visits, the mean reaction time was reduced to 2.37 seconds, and the deviation from the median was smaller compared to the results obtained in the first and second visits.

From Figure 4.7, it is evident that the participant's reaction time in their first visit is distributed relatively sparsely, from 2.52 to 8.84 sec. The second visit displayed an improvement in participants' responses, with the majority of the values converging towards the median value of 3.69 seconds. A few outliers, represented by "+" symbols in the plot, deviated from this central tendency. The participants' reaction times exhibited further improvement during the third visit, as evidenced by Figure 4.7. All response times were closely clustered around the median value of 3.03 seconds, indicating increased proficiency and familiarity with the system over time. This analysis demonstrates a consistent and significant improvement in participants' reaction times across multiple trials for all three functions (AP-On, AP-Off, and LKA), implying increased proficiency and familiarity with the system over time. The findings provide valuable insights into the learning curve and potential for user adaptation when engaging with advanced technological systems, highlighting the importance of clear demonstrations and user training.

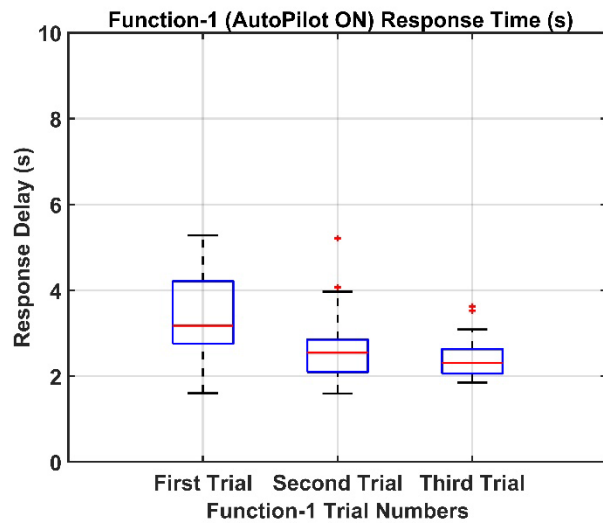


Figure 4.5: Visit number vs response time for AP function (On). “+” shows the outliers.

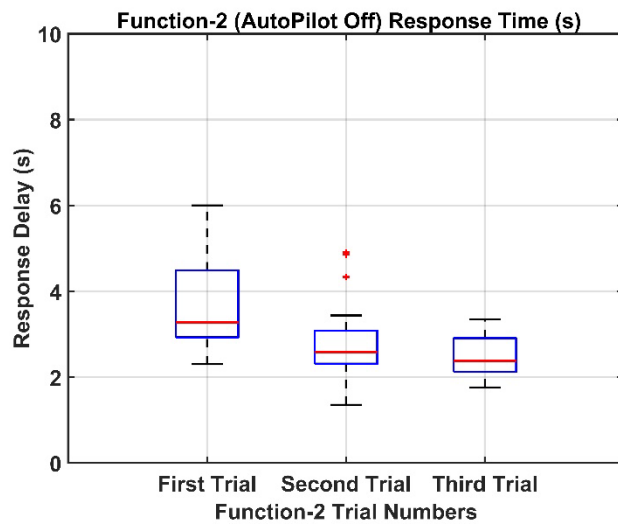


Figure 4.6: Visit number vs response time for AP function (Off). “+” shows the outliers.

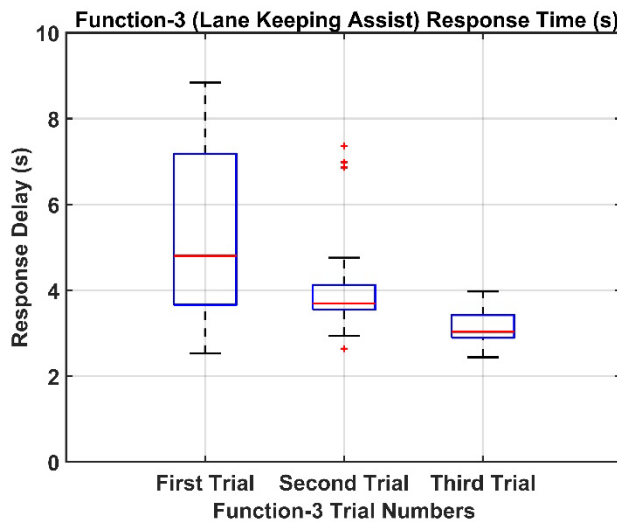


Figure 4.7: Visit number vs response time for LKA function (On). “+” shows the outliers.

4.4.3.2. Analysis of reaction time for functions not demonstrated in the introductory video

The results for Function 4-CA exhibit a distinct pattern compared to the first three (AP-On, AP-Off, and LKA) functions. This function was intentionally not demonstrated in the introductory video to simulate a real-world scenario where car dealers may only showcase a subset of functions to potential buyers due to various constraints and limitations. Consequently, the buyer must rely on the vehicle owner's manual to acquaint themselves with the remaining features. Figure 8 reveals that only one participant successfully activated the CA function during their first visit, with a response time of 8.28 seconds, which can be considered an outlier. Upon their second visit, after consulting the user manual, participants demonstrated improved performance, with a median response time of 4.22 seconds. In the third visit, participants exhibited further enhancement in their ability to activate the CA function, resulting in a reduced median response time of 3.62 seconds. Additionally, the deviation from the median was minimal, signifying a more consistent performance among participants.

Function 5-CC, which required participants to press two different buttons sequentially, also yielded distinct results. As the function is relatively complex and was not demonstrated in the introductory video, none of the participants successfully activated it during their first visit (Figure 4.9). Nevertheless, in the second visit, the response rate improved, with 50% of participants activating the

function correctly and a median response time of 6.95 seconds. In the third visit, the median response time was reduced to 4.95 seconds, with 100% accuracy.

These findings corroborate the observations discussed in Section 4.4.1, indicating that the most significant performance improvements can be achieved after two training sessions. The analysis emphasises the importance of providing adequate instructional resources and training opportunities to enhance users' proficiency in leveraging advanced vehicular functions.

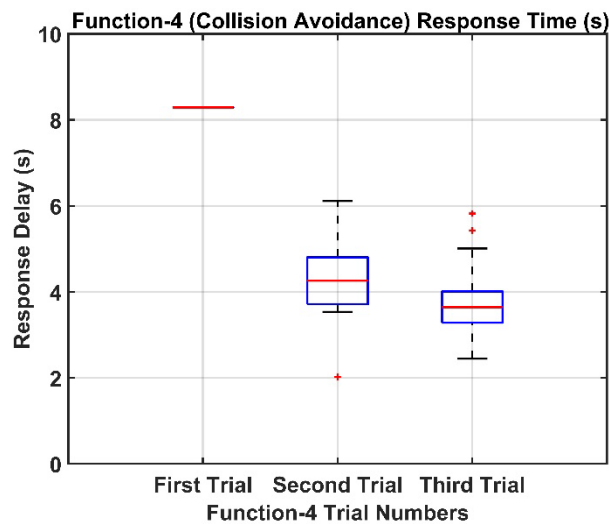


Figure 4.8: Visit number vs response time for CA function (On). “+” shows the outliers.

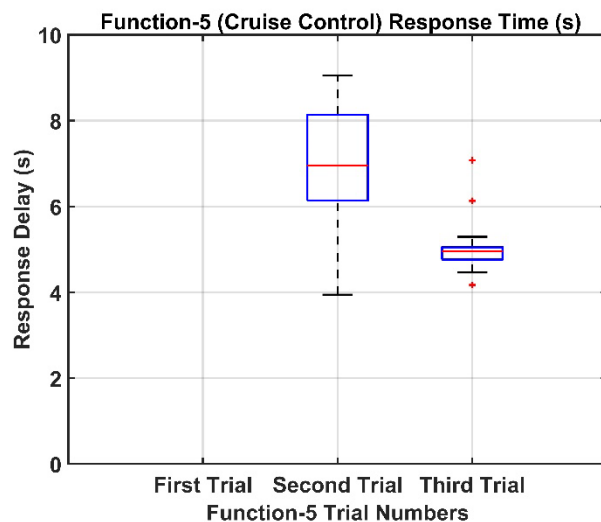


Figure 4.9: Visit number vs response time for CC function (On). “+” shows the outliers.

4.4.4. Impact of Training on Lateral Vehicle Control and ADAS Function Utilisation in Diverse Driving Scenarios

The experimental results from Section 4.4.3 indicate that training enables participants to enhance their accuracy in operating ADAS functions while reducing their reaction times. This section extends the analysis to examine the effect of driving practices and training on vehicle trajectory during the period between the issuance of verbal instruction and the participant's execution of the instructed action, such as pressing the LKA button. Section 4.4.3 discussed how driving practices and training contribute to decreased reaction times for activating or deactivating a specific ADAS function following verbal instructions. However, individual learning processes and behaviours may vary [131], and a longer reaction time does not necessarily indicate a lower learning outcome. For instance, a participant may deliberately delay their action due to the presence of vehicles in the adjacent lane during the experiment. Consequently, it is crucial to assess vehicle trajectory to determine whether the instructed action poses any risks to drivers and other road users, as it introduces an additional burden and mental workload. For a comprehensive analysis, we have selected six cases: three vehicle trajectories of a novice driver with minimal experience using ADAS functions in real life and three vehicle trajectories of an experienced driver who frequently uses ADAS functions, with each driver participating in three distinct trials.

4.4.4.1. Evaluating Vehicle Trajectory for Novice ADAS Users Across Three Trials

According to [132], the vehicle's lateral movement can be utilised to calculate the risk of a crash. Vehicle trajectory is a crucial parameter in determining driving precision and the safety of the SV and other road users [133]. The lateral movement of a vehicle can be quantified by calculating the RMSE value between the vehicle's lateral midpoint and the lane's lateral midpoint. We further examined the RMSE value between the vehicle's centre point and the lane's centre point to understand and contextualise the severity of the serpentine driving scenario. The RMSE value aids in quantifying the impact of the requested task on the vehicle's lateral movement and the extent of deviation that may occur due to driver engagement in secondary tasks. The RMSE of vehicle trajectory allows us to visualize the vehicle's deviation from the road's centre. Thus, RMSE serves as an effective indicator for evaluating drivers' performance in controlling the vehicle's lateral movement while engaged in secondary tasks.

In this paper, its expression is

$$\text{RMSE} = \sqrt{\frac{\sum_{n=1}^N (l_{\text{SV_mid_}n} - l_{\text{lane_mid}})^2}{N}},$$

where $l_{\text{SV_mid_}1}$ is the 1-st sample of the absolute lateral mid-point of the SV (its position in the simulated space from the right edge of the lane) collected right after the verbal instruction is issued, $l_{\text{SV_mid_}n}$ is the n-th sample of the lateral mid-point of the SV, and $l_{\text{lane_mid}}$ is the absolute lateral mid-point of the lane (its position in the simulated space from the right edge of the lane). An illustration of the process is shown in Figure 4.10.

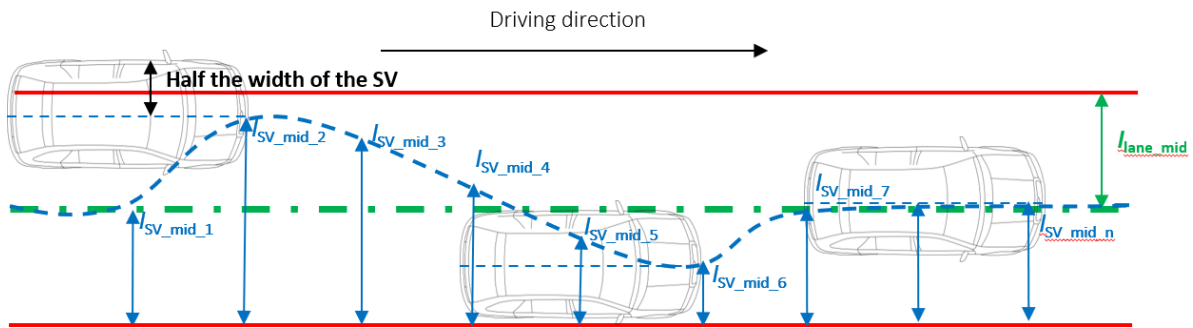


Figure 4.10: An illustration of the RMSE calculation process. The blue curve represents the absolute lateral mid-point of the SV (its position in the simulated space from the right edge of the lane) while the green line represents the absolute lateral mid-point of the lane (its position in the simulated space from the right edge of the lane). Samples of $l_{\text{SV_mid}}(t)$ are collected periodically along the trajectory.

Figure 4.11 displays a portion of the novice driver's vehicle trajectory during the first trial. The same driver's trajectories from the second and third trials are also extracted for comparison. In the novice driver's first trial, it took this single participant five seconds to locate and activate the LKA button. Figure 4.11 illustrates the substantial lateral movement of the novice driver's vehicle during the initial trial, with the vehicle deviating from the lane for a duration exceeding 2.6 seconds. This observation highlights a concerning high-risk scenario that could potentially lead to severe consequences, both for the subject vehicle and other road users. This phenomenon is described as serpentine driving behaviour by [132] and it is considered one of the major factors of a potential crash.

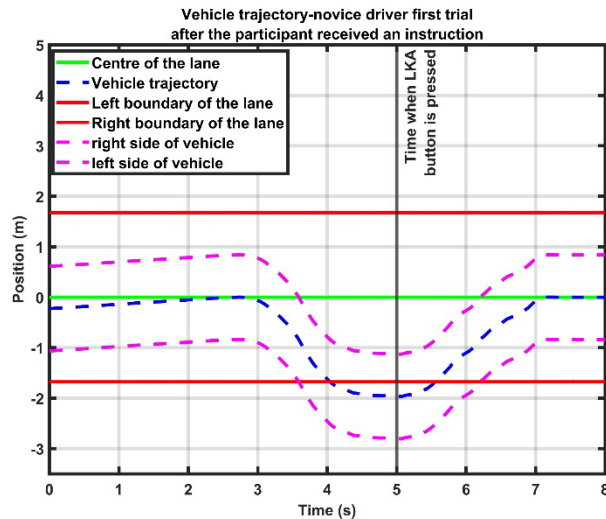


Figure 4.11: Vehicle trajectory of novice driver in the first trial after the participant received an instruction. The reaction time to press the LKA button in the first trial was 5.0 sec.

The primary tasks refer to the core driving activities that directly involve controlling the vehicle's motion and manoeuvring. In this paper, the interactions with the steering wheels, turning signals, and pedals were classified as the primary tasks. Additionally, we considered various interactions as secondary tasks, including interacting with the infotainment system, windows, air conditioning system, and buttons of ADAS functions. Secondary tasks encompass activities that may divert the driver's attention away from the primary driving task.

Engaging in a secondary task such as trying to locate an ADAS function button increased the driver's mental workload, consequently lowering their concentration on the vehicle's lateral movement. This finding aligns with [134, 135], who assert that when a driver is engaged in a secondary task, their mental workload may increase, leading to decreased driving performance. As a result, a serpentine driving scenario may arise, which is identified as one of the risk assessment matrices [132].

In the first trial, the novice driver obtained an RMSE value of 1.03 meters, which is relatively high considering the subject vehicle and lane widths of 1.676 meters and 3.352 meters, respectively. Figure 4.12, however, illustrates an improvement in the trajectory of the same participant during the second trial, demonstrating not only a reduced reaction time but also enhanced control over the vehicle's lateral movement. In the second trial, the vehicle's right side veered off the lane for only 0.52 seconds, a reduction of over 70%. Figure 4.13 further demonstrates that with increased practice, the novice driver becomes more proficient in locating and activating ADAS functions while driving. The corresponding RMSE values in Table 4.4 corroborate these observations, showing an

improvement in the novice driver's RMSE value from 1.03 meters to 0.36 meters between the first and third trials. These results align with our initial findings discussed in Sections 4.4.2 and 4.4.3, which suggest that after two practice sessions, improvements in accuracy, reaction time, and vehicle control during secondary task performance become apparent.

According to [136], operating vehicles equipped with ADAS functions necessitates a different skill set from traditional driving. These authors further contend that with the integration of automation technology, the human driver assumes a more observatory role, only needing to take control of the vehicle in case of system failure. Our findings align with those of [134], indicating that drivers' takeover performance improves with increased practice opportunities. Our results also concur with those of [131], who maintain that practice enhances drivers' ability to handle complex driving situations. Consequently, drivers are better equipped to manage complex driving scenarios while simultaneously utilising ADAS functions.

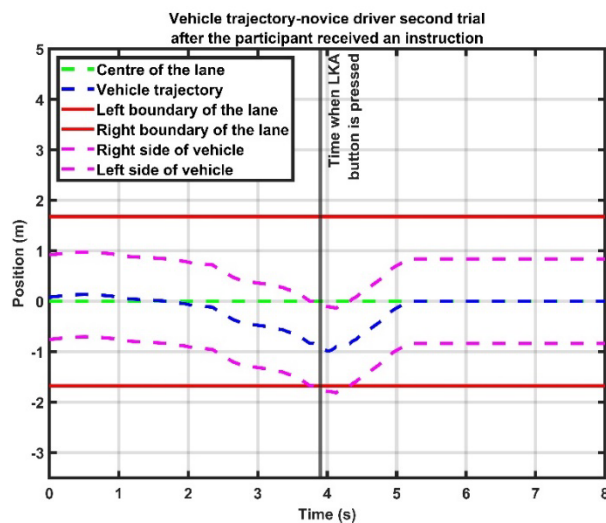


Figure 4.12: Vehicle trajectory of novice driver in the second trial after the participant received an instruction. The reaction time to press the LKA button in the second trial was 3.9 sec.

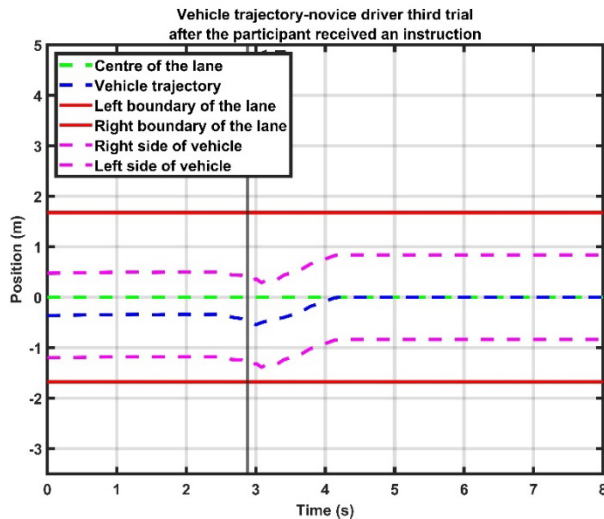


Figure 4.13: Vehicle trajectory of novice driver in the third trial after the participant received an instruction. The reaction time to press the LKA button in the third trial was 2.88 sec.

4.4.4.2. Evaluating Vehicle Trajectory for Experienced ADAS Users Across Three Trials

We also examined the driving behaviour of experienced drivers who regularly use ADAS functions in real-world driving scenarios. We analysed data from all three trials to assess the impact of practice on vehicle control while engaged in a secondary task (in this case, activating the LKA function). Comparing Figure 4.11 and Figure 4.14, the vehicle trajectory of the experienced driver demonstrates greater uniformity and reduced lateral movement compared to the less experienced driver, as depicted in Figure 4.11. For the novice driver, the right side of the vehicle deviated from the lane's centre for 2.6 seconds. In contrast, Figure 4.14 reveals that the right side of the experienced driver's vehicle crossed the boundary of the desired lane for only 0.37 seconds between 3.72 and 4.09 seconds. This observation suggests that driving experience contributes to improved control over the vehicle's lateral positioning compared to that of novice drivers. These findings are consistent with those of [135].

It is crucial to recognise that training remains important even for experienced drivers, as it helps them refine their mental models while operating vehicles equipped with ADAS functions [27, 136]. In this work, the term “mental model” refers to drivers' knowledge and understanding of a system's automation, limitations, and capabilities, which plays a vital role in ensuring the safe and appropriate use of complex systems. These mental models inform decision-making and guide interactions with the systems. Accurate and well-developed mental models enhance drivers' ability to effectively and

safely utilise these systems [137, 138]. Training further enables them to calibrate their trust in alignment with their understanding of system capabilities, allowing drivers to responsibly reallocate attention to anticipate and prevent hazardous driving conditions [27, 88]. Figure 4.15 and Figure 4.16, which display the vehicle trajectories of the same experienced driver in trials 2 and 3, respectively, demonstrate more uniform vehicle lateral movement and a tendency toward the lane's centre. Notably, the vehicle remained within the lane in trials 2 and 3, indicating improved vehicle control after the initial training opportunity.

A comparison of experienced drivers' results from trials one to three suggests that even experienced drivers may initially struggle to utilise ADAS functions when first exposed to them. As observed in Figure 4.14, the vehicle was outside the desired lane for 0.37 seconds during the first trial. Nevertheless, the experience enabled these drivers to learn and adapt to the ADAS functions more rapidly. According to [88, 136], experience facilitates quick adaptation to situations and the development of accurate mental models. Thus, we can conclude that training is essential even for experienced drivers, as it allows them to learn and locate the buttons more efficiently. Table 4.4 also demonstrates that the RMSE improved through engagement in practice sessions. For experienced drivers, the RMSE decreased consistently from 0.58 to 0.39 and finally to 0.09 in the first, second, and third trials, respectively, representing an improvement of over 80%. These findings are consistent with our earlier observations discussed in Section 4.4.3, which indicated that significant improvements can be seen after two training sessions.

From the above results, we can conclude that training helps one to develop the best mental model for safe driving i.e., it helps the driver to improve accuracy in recalling the location of the ADAS and AV buttons. The effective and efficient use of ADAS and AV functions can help to significantly reduce the number of crashes on the road [19]. It also helped to minimize the reaction time in case of system failure which is consistent with the works of [131, 136]. Lastly, through the training process, we can develop the best mental model for the road and infrastructure environment and vehicle environment, which helps you better control vehicle manoeuvres. This concurs with [136].

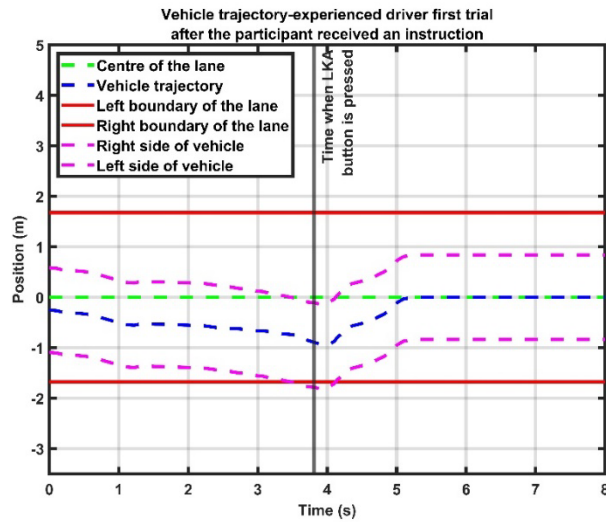


Figure 4.14: Vehicle trajectory of the experienced driver in the first trial after the participant received an instruction. The reaction time to press the LKA button in the second trial was 3.81 sec.

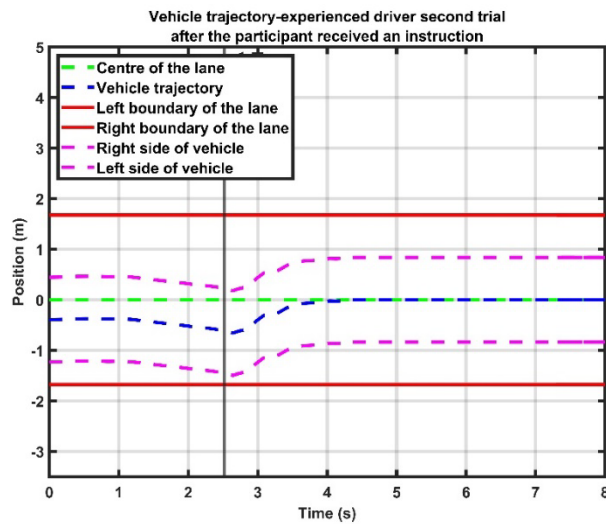


Figure 4.15: Vehicle trajectory of the experienced driver in the second trial after the participant received an instruction. The reaction time to press the LKA button in the second trial was 2.52 sec.

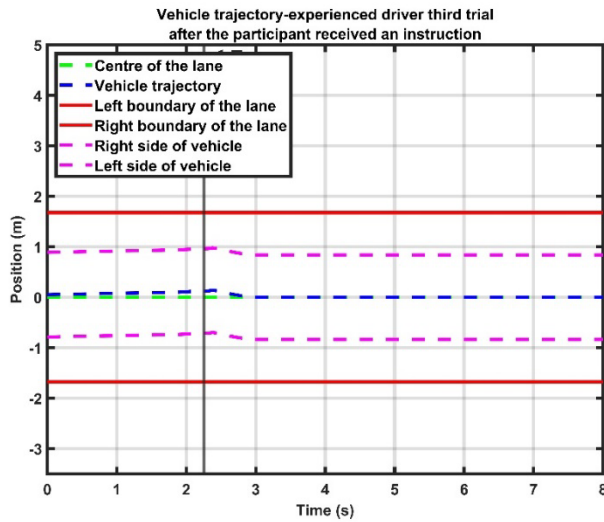


Figure 4.16: Vehicle trajectory of the experienced driver in the third trial after the participant received an instruction. Reaction time to press the LKA button in the second trial was 2.25 sec

Table 4.4: Participant's RMSE in each trial

Groups-Division w.r.t driving experience and ADAS function frequency of use	Trial/Visit No-1 RMSE in meter	Trial/Visit No-2 RMSE in meter	Trial/Visit No-3 RMSE in meter
Group-4 (1-3 years) and Never used ADAS functions	1.03	0.51	0.36
Group-6 (Above 8 years) Regularly use ADAS functions	0.58	0.39	0.09

4.4.4.3. Impact of Training on Lateral Vehicle Control and ADAS functions' utilisation: Reduced Driving Risk Across Trials

According to [132], assessing the risk of serpentine driving and the associated risk to other road users due to the corresponding disturbance can be achieved by analysing the vehicle's lateral position relative to the centre of the road. To investigate the impact of training on drivers' ability to control lateral movement while interacting with different ADAS functions via the given panel, we examined the vehicle trajectories of two participants. These results are further discussed in detail in Sections 4.4.1 and 4.4.2, one from Group 4 (drivers who reported never having used ADAS functions before) and another from Group 6 (drivers who regularly use ADAS functions). Our observations indicated a progressive reduction in RMSE values with subsequent training and practice sessions. Thus, we

deemed it essential to analyse the RMSE for all users to evaluate the impact of training on drivers' ability to control lateral vehicle movement while activating/deactivating ADAS functions.

Figure 4.17 illustrates the RMSE values for vehicle lateral movement among all participants in the experiment in three different trials. As depicted in Figure 4.17, the median RMSE value for all participants significantly decreased from 0.70 meters in the first trial to 0.4 meters in the second trial and further reduced to 0.27 meters in the third trial. This substantial improvement in RMSE values aligns with the observed decrease in reaction time for locating and activating the ADAS function button across consecutive trials. Consequently, our study emphasises the crucial role of ongoing training and practice for drivers with varying experience levels to maximize the safety interactions and use of ADAS functions in real-world driving situations.

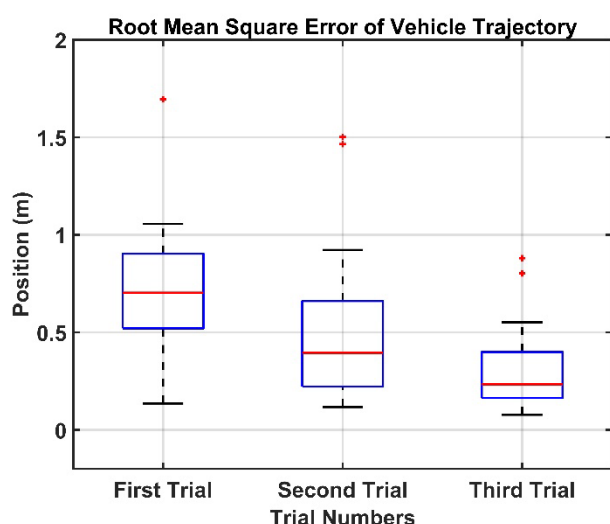


Figure 4.17: RMSE value in meters for all participants in three different trials

4.5. Discussion

Our analysis highlights the crucial roles of 1) driving experience and 2) consistent utilisation of ADAS functions in determining a driver's proficiency in activating and managing these systems. Both experienced drivers and those who frequently engage with ADAS features exhibited superior performance in ADAS activation tasks compared to novice drivers and infrequent users. The results imply that driving experience aids drivers in learning and locating buttons more rapidly; however, it does not negate the importance of supplementary training. Moreover, the continuous use of ADAS

functions promotes long-term retention of acquired skills, thus diminishing the necessity for regular refresher training. This finding indicates that consistent practice facilitates knowledge consolidation, allowing it to become deeply embedded within the driver's memory for more effective retrieval and application. This observation aligns with the research conducted by [130]. In summary, our findings corroborate those of [129], demonstrating that the most significant improvement is observed after two training sessions, especially for drivers who do not routinely use ADAS functions while driving.

Our findings further emphasise the value of providing comprehensive training for end-users of ADAS and autonomous driving technologies, regardless of their driving experience. Implementing such training programs can enhance these advanced systems' safe and efficient use, ultimately improving road safety. However, a balance should be obtained to avoid learning fatigue [139, 140]. The training should also be carefully designed to ensure that the content is delivered intuitively, effectively, and engagingly.

The analysis of reaction times for the three functions presented in the introductory video (AP-On, AP-Off, and LKA) and those not demonstrated (Function 4-CA and Function 5-CC) provides valuable insights into users' learning curves of those advanced vehicular functions. Findings revealed that participants exhibited significant improvements in reaction times across multiple trials for both sets of functions. The most notable performance enhancements were observed after two training sessions, emphasising the importance of a combination of clear demonstrations, user training, and adequate instructional resources.

This study investigated the impact of training on lateral vehicle control when utilising ADAS functions across diverse driving scenarios, focusing on both novice and experienced drivers. Our findings revealed that training and practice sessions significantly improved reaction times, accuracy, and vehicle control, particularly when engaging with secondary tasks. This emphasises the importance of training for drivers of all experience levels to develop accurate mental models and enhance their proficiency in using ADAS functions.

Our analysis of vehicle trajectories demonstrated noticeable improvements in lateral control and reduced reaction times for novice drivers across trials. Similarly, experienced drivers also benefited from training and practice sessions, as evidenced by the consistent decrease in RMSE values across trials. These results highlight the necessity of training to refine mental models and deepen understanding of ADAS and AV functions, even for experienced drivers. The study's findings align

with previous research [136], emphasising the role of training in fostering accurate mental models and effective ADAS function utilisation. The observed decrease in RMSE values for all participants across consecutive trials reinforces the importance of ongoing training and practice for maximising safety benefits and efficient ADAS function use in real-world driving situations.

Our study underscores the significance of comprehensive training and practice opportunities for drivers with varying experience levels in enhancing ADAS function proficiency. These insights have valuable implications for designing effective training approaches and promoting user engagement with advanced vehicle technologies, ultimately contributing to improved driving safety and performance.

4.6. Chapter Summary

Chapter 4 of the thesis explored the significant impact of training on driver performance within the context of ADAS and AV. Through a simulation-based research design involving a diverse group of participants, the chapter investigated how structured training sessions influenced novice and experienced drivers regarding accuracy, reaction time, and vehicle control when using ADAS features. Key findings revealed that all participants, irrespective of their driving experience, showed marked improvements in driving performance after the training sessions. These improvements underscored the necessity of rigorous training regimes akin to those used in aviation and maritime industries, highlighting the complexity and critical nature of operating modern vehicles equipped with advanced technological systems.

The research further analysed how experience and frequency of ADAS usage affected learning outcomes, indicating that while experienced drivers may learn faster, continuous and comprehensive training is crucial for all. The study also suggested that regular interaction with ADAS can decrease the need for frequent retraining by enhancing long-term skill retention. Importantly, the chapter provides insights into how training influences lateral vehicle control, a critical factor for evaluating the risk of crashes. Enhanced training helps significantly reduce the RMSE of vehicle trajectory, directly correlating with improved safety and reduced likelihood of crashes in diverse driving scenarios.

Additionally, the chapter discusses the broader implications of these results for stakeholders, including policymakers, vehicle manufacturers, and driver education providers, advocating for

enhanced driver training curricula. Future research directions are proposed, focusing on AI-assisted coaching and real-time feedback systems to further refine training effectiveness. Overall, the findings from this chapter are pivotal for advancing the safety and efficiency of road transport in the era of increasing vehicle automation, emphasising the critical role of tailored and repeated training sessions in preparing drivers for the future of driving.

Chapter 5: Evaluating LLM-Augmented Training for Advanced Driving Technologies

This chapter explores a comprehensive comparative analysis between conventional driver education methods and an innovative LLM-augmented training approach tailored explicitly for AV technologies. As the shift in vehicular technology advances towards more sophisticated ADAS and AV, there is a corresponding need to evolve training methods to prepare drivers for these advanced functionalities effectively. This study rigorously compares conventional, including both paper and video-based, training methods with a novel instructional tool, LLM-based training, exemplified by ChatGPT. The chapter details the methodology of educating two distinct groups of participants: one with conventional instructional techniques and the other with LLM-augmented methods. By focusing on essential metrics such as reaction times and accuracy in activating ADAS and AV functions, the research aims to quantify the efficacy and efficiency of these educational approaches. The results from the study revealed that the group trained via ChatGPT exhibited significant improvements in their learning outcomes. This included shorter activation times, higher consistency, and enhancement in accuracy across all examined functions. The findings indicate that participants who engaged with ChatGPT-based training scored higher (on average, 21% higher) in accuracy in activating ADAS functions. A statistically significant reduction in activation time for all the functions was also observed, such that $P < 0.05$.

Furthermore, the chapter introduces a strategic framework developed to maximise the potential of LLMs like ChatGPT in driver education. This framework enables educators to customise interactions and provide targeted, effective learning experiences. The chapter presents empirical evidence supporting the effectiveness of LLM-augmented training and discusses its broader implications for the future of educational practices in technologically advanced systems. Through this analysis, the

chapter establishes a foundational perspective for integrating artificial intelligence in educational strategies, offering insights into its scalable application across various learning environments and systems.

5.1. Introduction

The rise and rapid proliferation of ADAS and AV constitute a significant transformation in the automotive industry, possessing the potential to reshape transportation systems across the globe drastically [1, 2] and offer various benefits, notably increased safety [3], enhanced mobility, and a substantial reduction in traffic congestion [1]. Human factors contribute to more than 90% of accidents, according to Australia's NRSP [31]. The technology-driven shifts triggered by the advancements in ADAS, and AVs can significantly mitigate human-related accidents, which remain one of the leading causes of road casualties worldwide. The capabilities of AVs vary based on their level of automation, as categorised by the SAE, ranging from no driving automation (level 0) to full automation (level 5) [9]. However, the introduction of these sophisticated systems raises a fundamental question: How can human drivers be effectively trained to safely interact and cooperate with vehicles with ADAS functions or AVs [31]?

The seamless operation and utilisation of ADAS functions and AVs largely depend upon drivers' comprehensive understanding and ability to control these advanced systems effectively, which could be obstructed by several barriers. These include the lack of standardisation across manufacturers [19] and the lack of specific training, practising platforms and opportunities [31]. The urgency of addressing these concerns is highlighted by the growing consensus among the research community about the critical role of appropriate training in availing the full potential of AV technology [3, 27].

The automotive industry and academia have invested considerable resources into training to ensure trainees have the competencies to perform their tasks safely and effectively [28]. Existing training programs primarily focus on fostering confidence and imparting necessary skills in individuals, enabling them to interact with advanced systems with high proficiency and safety [17, 18]. The range of conventional training methods spans from paper-based, video-based instructions to demonstration-based and trial-and-error techniques.

This variance in training methods is evident across sectors. For instance, modern current vehicle driver training in the automotive industry relies on user manuals, demonstrations at dealerships,

videos, information brochures, and trial and error [3, 18, 29-31], while forklift driving and situational awareness cycling also employ video-based instruction [141, 142]. In the aviation industry, pilot training employs simulation-based and video-based methods [143-145], while the software development industry utilises both video and paper-based methods [93, 94]. Similarly, video and paper-based training is used in the medical field to instruct medical procedures and train staff, including physiotherapists [146, 147]. This diversity in training approaches across various industries underscores the importance of tailoring instructional methods to specific sector requirements and learning objectives, emphasising the evolving nature of educational techniques in response to technological advancements and industry-specific needs.

Understanding drivers' interaction with ADAS functions and AVs is grounded in mental models, which represent drivers' knowledge and comprehension of these advanced in-vehicle systems [100]. These mental models can be shaped by different formal and/or informal training methods, such as trial-and-error, user manuals [15], dealership demonstrations [18], and video-based training [3]. An accurate mental model allows drivers to utilise ADAS effectively and safely, while an inaccurate model can lead to misuse, over-reliance, and potentially dangerous situations [18]. Hence, choosing effective training methods is crucial in developing accurate mental models, enhancing drivers' understanding of ADAS functions, and ensuring safer interaction with these systems [31].

Currently, there is a lack of a formal training platform specifically designed for drivers of modern vehicles equipped with ADAS functions. According to [35], the recent launch of ChatGPT has been a historic breakthrough for the application of AI within the realm of education. Several studies [37-50, 101] have evidenced the potential of LLMs, such as ChatGPT, in enhancing learning outcomes, learner motivation, engagement, customised support and output presentation, consistency, and scalability in training across a wide range of industries, including automotive, transportation, aviation, maritime, medical, education, information systems, and construction. However, to our knowledge, no comprehensive study discusses how an LLM-augmented approach can be employed as an effective training tool for ADAS functions or AVs.

Consequently, this study seeks to investigate this unexplored area by offering a systematic framework for using ChatGPT's LLM as a training tool for drivers to use ADAS functions and AVs in the future. By leveraging our LLM-augmented approach's cognitive and dialogic capabilities, we aim to enhance users' understanding of ADAS, thereby improving their interactions with these systems and ensuring safer and more efficient driving experiences. The efficacy of the ChatGPT-based training

approach was evaluated in an empirical study and compared with conventional training methods for operating ADAS functions. Participants' performance, as measured by their accuracies and reaction times in interacting with ADAS functions, served as a primary metric for assessing the effectiveness of different training methods. By investigating the cognitive underpinnings of learning and understanding ADAS functions, this research attempts to reveal how different training methods can influence the formation of mental models, thereby impacting the utilisation of ADAS functions.

In this study, we utilised ChatGPT's capabilities to develop an interactive training program for teaching drivers how to use ADAS functions and AV capabilities. ChatGPT was asked to digest the contents of simulated ADAS and AV manuals and convey this information through a conversational, interactive medium that adapts to users' responses. The training content was developed by inputting manual descriptions into ChatGPT. This information was transformed into clear, conversational language suitable for learners with little or no relevant technical backgrounds. By doing so, ChatGPT provided personalised guidance, clarified user queries, and verified understanding through targeted follow-up questions. This methodology was designed to impart knowledge and engage users in a two-way dialogue, fostering a deeper understanding of ADAS functionalities and enhancing the learning experience. To ensure the consistency and accuracy of the information provided, in the experiment, ChatGPT was restricted to using only the data from the manuals, avoiding any external knowledge sources. The technical implementation of this approach utilised the foundation of instructional design and the science of learning to enhance the effectiveness of the ChatGPT-facilitated training.

The findings of this study hold implications for both the automotive industry and educators, suggesting practical strategies for ADAS training that can be incorporated into driver education programs, dealership demonstrations, and user manuals. As the automotive landscape shifts towards increased automation, it becomes imperative to re-evaluate our training methodologies. This study offers a novel perspective by integrating LLMs into the training process, providing a promising avenue for enhancing drivers' comprehension of ADAS functions and ensuring safer road experiences in an era of automation.

The remainder of this chapter is organised as follows: Section 5.2 presents the methodology, experimental setup, and driving environment. Section 5.3 describes the recruitment process and the composition of the participants. In the same section, we also discussed the framework for effectively using the ChatGPT prompt for training purposes. Section 5.4 discusses the Framework for Preparing

a ChatGPT prompt for training, assessment of ChatGPT's response accuracy, and strategies for preparing learners to interact effectively with LLM-based tools. Section 5.5 compares the two training methods, conventional vs ChatGPT, by analysing their corresponding participants' accuracy and LLM-based response time when interacting with ADAS functions. Section 5.6 compares various training methods and the significance of ChatGPT-based training and its applications in other industries. Based on the findings and analyses, recommendations for stakeholders and concluding remarks are provided in Section 5.7.

5.2. Methodology

5.2.1. Experiment Setup

The experiment was conducted using a York driving simulator, interfaced with a Logitech G27 racing wheel system comprising pedals and a shifter module. An array of ADAS functions (detailed in Table 5.1) were assigned to specific buttons on the steering wheel and the shifter module to mimic an authentic driving environment.

The experimental methodology encompassed manoeuvres of an AV in a three-dimensional virtual setting. This vehicle was either autonomous or controlled by the participant, with ADAS functions in either an activated or deactivated state. The simulated AV was equipped with an automatic transmission feature, enabling the panel on the shifter module to be dedicated entirely to the activation and deactivation of ADAS functions. Consequently, the shifter lever was disabled for the duration of the experiment.

To enhance the ecological validity of the experiment, thorough attention to detail was exerted in the design process to emulate a highly authentic and immersive driving experience. This setup is visually represented in Figures 5.1 and 5.2. Figure 5.1 identifies components "a" to "c" as the steering wheel, pedals, and driving seat. Figure 5.2 displays components "d" to "h", signifying distinct aspects of the setup and their corresponding ADAS functions.

In Figure 5.2, component "d" illustrates the location of the LKA button on the shifter module. Component "e" shows the positioning of the Autopilot-On (AP-On) function on the steering wheel. The ACC function, represented by component "f", is positioned on the shifter module. Component "g" indicates the location of the Autopilot-Off (AP-Off) function on the steering wheel, and

component “h” highlights the CA function, also located on the steering wheel. This exhaustive labelling and description provide a comprehensive overview of the experimental setup, contributing to the experiment's reproducibility.

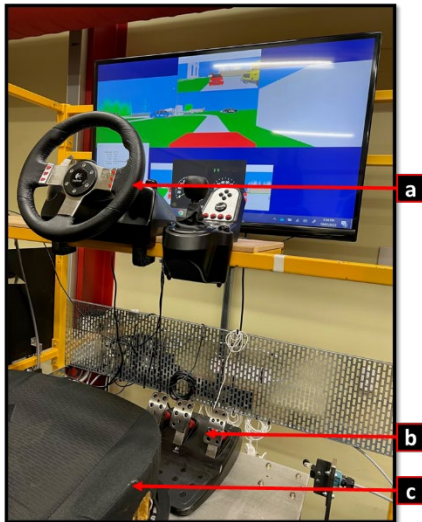


Figure 5.1: *[Experiment setup [a: steering wheel, b: pedals, c: driving seat]*



Figure 5.2: *ADAS functions' locations [d: LKA, e: AP-On, f: ACC, g: AP-Off, h: CA]*

5.2.2. Driving Scenario and Environment

The driving simulator's interface is shown in Figure 5.4, where the red box stands for the front of the vehicle, i.e., the bonnet. The dashboard, which includes a speedometer and indicators for the ADAS functions, is displayed underneath that. These indicators light up in green to show when the functions are ON, as illustrated in Figure 5.4, indicating, for example, that the LKA function is active. The 3D simulated environment incorporates several key features that one can find on a real road, such as different traffic densities, streetlights, road signs, pedestrians, speed zones, buildings, and

vegetation. These features help participants better understand their environment within the simulation [127].

Figure 5.3 shows a bird's-eye view of the driving route, with a red circle showing where the vehicle starts. The route's low-speed (50 km/h) and high-speed (100 km/h) zones are indicated with red and blue arrows, respectively. These zones mimic city and highway driving changes, providing participants with different driving experiences. During each test, participants were told to start from the low-speed zone, cross an intersection, enter the high-speed zone, cross the intersection again, and then return to the low-speed zone. Several triggers (T1 to T5) along the route start different events as the vehicle passes, as shown in Figure 3. Table 5.1 shows the instructions linked to these triggers. When the vehicle passes a trigger, an audio instruction from Table 5.1 is played, asking the participant to act accordingly. Out of the five actions, only the ACC requires two buttons to be pressed sequentially, and the others can be activated with one button. In this work, we analyse data on the steering angle, the utilisation of acceleration and braking, the times when events were triggered, and drivers' response time to these events. We measured how accurately (as a percentage) participants used the correct ADAS functions and how long they took to respond (in seconds).

Table 5.1: Instruction for each trigger

Trigger no	Instruction
T1	Turn on the auto-pilot function
T2	Turn off the auto-pilot function.
T3	Turn on the lane-keeping assist function.
T4	Turn on the collision avoidance function.
T5	Turn on the adaptive cruise control function.

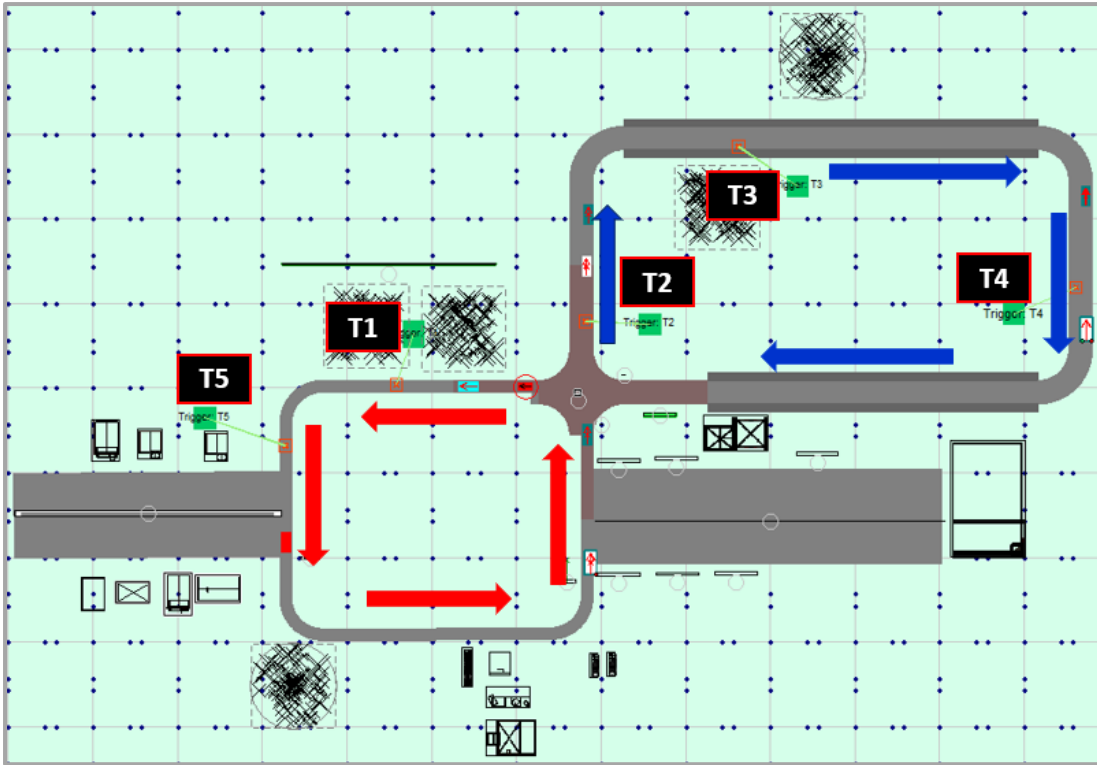


Figure 5.3: An overview of the simulated driving scenario [red and blue arrows indicate the low-speed and high-speed zones, respectively].



Figure 5.4: A snapshot of the simulator interface [i: Rear mirror view, j: front of the simulated AV, k: Shows LKA function is ON, l: right side mirror, m: speedometer, n: left side mirror view, o: AV current parameters]

5.3. Recruitment of Participants

The sample comprised various ages and genders to maintain heterogeneity. The participant recruitment was conducted via a hybrid approach, utilising both digital and conventional methods. In this study, we recruited a diverse sample of participants, including RMIT University students, staff, and members of the general public interested in AV research. To recruit participants, we leveraged the university's online platform, including webpages, emails, and online forms. This effort was complemented by paper-based advertisements, i.e., posters and leaflets, distributed throughout RMIT University's Bundoora campus.

Data collection was extended over six months to ensure a sufficiently large and representative dataset for subsequent analyses. Our final sample group consisted of 86 adult participants aged 20 to above 40 years old, as detailed in Table 5.2. All participants had driving experience ranging from novice (one to three years), intermediate (four to six years), to experienced (over six years), as outlined in Table 5.3. This division of driving experience categorisation is consistent with established road safety and insurance benchmarks for defining driver expertise [148, 149]. Additionally, participants were categorised based on their frequency of ADAS function usage, and this information is presented in Table 5.4. In this study, we only collected the above information in ranges instead of their absolute values due to privacy concerns, which were essential for our ethics approval application. In the experiment, participants were divided into two distinct learning groups. They were randomly allocated to each group to enhance the validity of the comparison between training methods. Group 1, the conventional learning group, comprised 46 participants trained through video presentations and user manuals. Group 2 comprised 40 participants who received training through a ChatGPT-based learning platform. Both groups had an almost balanced gender distribution, with the first group having 26 males and 20 females and the second group comprising 23 males and 17 females. A prerequisite for all participants was to hold a valid driving licence.

Table 5.2: Participants division w.r.t age group

Training type	Number of participants	Age group (20 – 30 years)	Age group (30 – 40 years)	Age group (Above 40 years)
Conventional learning group	46	20	14	12
ChatGPT-based learning group	40	18	12	10

Table 5.3: Participants division w.r.t driving experience

Training type	Number of participants	Driving experience Novice driver (1-3 years)	Driving experience Intermediate driver (4-6 years)	Driving experience (Experienced driver (Above 6 years)
Conventional learning group	46	14	13	19
ChatGPT-based learning group	40	13	11	16

Table 5.4: Participant's division w.r.t ADAS functions frequency of use

Training type	Number of participants	Novice/Occasional user	Intermittent user	Regular user
Conventional learning group	46	15	17	14
ChatGPT-based learning group	40	13	15	12

To prevent potential bias, we carefully chose participants from a wide array of academic disciplines, thereby ensuring a diverse representation of educational backgrounds. Additionally, we extended invitations to the general public, attracting participants from various backgrounds and enhancing our dataset's diversity. Before initiating the experiment, all participants were comprehensively briefed about the study's objectives and procedures. Informed consent was obtained from all participants, ensuring their voluntary and informed participation.

Given the categorical nature of our data, we conducted Pearson's Chi-Square tests for our analysis. This test is suitable for comparing frequencies across categorical variables [150]. The Mann-Whitney

U test was not considered appropriate because it is intended for continuous or ordinal data with individual scores, which does not match our dataset's characteristics [150, 151].

We conducted statistical analyses to assess the comparability of participant characteristics between the two learning groups. The results of Pearson Chi-Square tests revealed no statistically significant association between the training group type and gender ($p = 0.927$), age distribution ($p = 0.989$), driving experience levels ($p = 0.979$), and ADAS use frequency ($p = 0.998$). All p -values were above the standard significance threshold of $p < 0.05$. These findings indicate that the observed differences between the conventional learning group and the ChatGPT-based learning group were not statistically significant, suggesting a balanced distribution of participants across key demographic and experiential variables. This equivalence between groups supports the validity of comparisons made in subsequent analyses of training effectiveness.

The experimental protocol was subjected to a thorough review process and was approved by the RMIT University Human Research Ethics Committee (Approval Number: EC 25022). This ensured adherence to the ethical standards and guidelines incumbent on academic research.

5.3.1. Participant's Registration and Briefing Session

Upon arrival at the experiment site, all participants were guided through a standardised registration process. They were provided with a comprehensive explanation of the experiment's setup, objectives, and potential implications. Each participant was presented with a "Participant Information and Consent Form," which had received prior approval from the RMIT University Human Research Ethics Committee. After going through the details mentioned in the form, participants gave informed consent to participate in the study by signing the form. Subsequently, all participants were introduced to the project through a concise video. This video aimed to set the context for the experiment rather than serving as part of the training process.

5.3.2. Group 1 Training: Conventional Method

Following the introductory video, group 1 participants proceeded with their training session. This session commenced with an informative video lasting approximately ten minutes, demonstrating the project's objectives, hardware setup, virtual driving environment, route, and three of the five ADAS functions.

The video's decision to focus on only three ADAS functions was informed by the need to simulate the experience of purchasing a new vehicle, where car dealers typically showcase a limited number of key functions due to time constraints and legal limitations [152]. Meticulous design underscored this methodology to ensure an accurate explanation of the experiment setup and a professional demonstration of the ADAS functions. To maintain consistency across the study and ensure that all participants receive the same level of information, video recordings were utilised as the medium for training and demonstration. This approach aligns with the findings of [3, 88], who suggest video-based training as one of the highly effective methods.

After the video, participants were presented with a comprehensive user manual in printed form that was structured to emulate the look and feel of an actual vehicle owner's manual while being tailored for the experimental setup. The length of this user manual was around 1100 words. This manual consisted of three sections. The first section overviews the driving simulator's interface, layout, and operations. The second section offered detailed descriptions of all five ADAS functions' functionality and activation/deactivation processes, extending beyond the three discussed in the video. The final section outlined the boundaries and limitations of each ADAS function. Participants were given 15 minutes to read and understand the manual, emphasising the remaining two ADAS functions not covered in the video. Time allocation to read the user manual is consistent with that mentioned in [17]. The 15-minute time allocation for reading the manual was carefully chosen to maintain uniform experimental conditions across the conventional and ChatGPT groups, accounting for consistency and logistical constraints within the study design. By standardising the duration, we aimed to minimise variability in exposure to the instructional material, thus providing a fair baseline for comparing training effectiveness across demographically diverse participants. This approach ensures that any observed differences in the outcomes can be more confidently attributed to the training methods rather than differences in the time spent with the manual. According to [153], a non-native English speaker reads an average of 139 words per minute; hence, our manual was designed to be comfortably read in around 8 minutes, providing ample time for participants to review sections as needed, mainly the two ADAS functions not covered in the instructional video. After training, all participants were invited to drive the AV in a simulated environment.

5.3.3. Group 2 Training: ChatGPT-Based Interactive User Manual

Group 2 participants underwent a distinctive training approach. Instead of the conventional method, they were introduced to a ChatGPT-based interactive user manual, with training conducted directly on a simulator screen. While the text content of the user manual remained the same for both groups, the delivery method differed significantly. This innovative approach, utilising the ChatGPT-based manual, aimed to create a more engaging and efficient learning environment within a 15-minute training session.

The ChatGPT prompt has been specifically modified to instruct participants on using numerous ADAS functions of the simulated AV, a process comprehensively discussed in Section 3.3.1. It is imperative to note that there is no imposed limit on the number or length of questions that participants can put forward to ChatGPT. This open-ended approach is intended to provide users with a more expansive and flexible learning environment. Participants are thus given the liberty to ask any number of questions, regardless of their complexity or scope, within 15 minutes. The rationale behind this procedure is to ensure that participants have ample opportunity to explore and understand the AV's operations deeply and comprehensively within a reasonable time frame.

According to [43], it has been noted that instructions delivered via ChatGPT can occasionally be vague or unrelated to the context if not properly structured. This observation aligns with the findings of [154], who asserted that poorly constructed queries or instructions may elicit incorrect or irrelevant responses from the LLMs. Consequently, to ensure that ChatGPT provides accurate instructions tailored to a specific scenario, it becomes imperative to furnish the system with ample context and detailed information.

In this study, we proposed a comprehensive set of guidelines to optimise communication with ChatGPT. These guidelines describe the most effective strategies for structuring queries and instructions to obtain the expected and most beneficial responses from the LLM-augmented approach. By adhering to these guidelines, users can maximise the potential of ChatGPT and facilitate more accurate and contextually relevant outputs, thereby enhancing the overall effectiveness of the interactive training sessions. It is important to highlight that participants were not required to create prompts to interact with ChatGPT. This aspect was managed by providing pre-designed prompts designed by the Author, as detailed in Section 5.4 of the thesis.

5.4. Framework for Preparing a ChatGPT Prompt for Training

The development and application of instructional content through ChatGPT requires a detailed understanding of the context and background information relevant to the training scenario. This paper introduces a comprehensive framework aimed at optimising the creation and delivery of ChatGPT prompts for a variety of training domains. Although our primary focus is on ADAS and AV driver training, our framework's principles are broadly applicable, extending to diverse industries beyond AV training. The framework is structured around a set of guiding principles that enhance the instructional effectiveness of ChatGPT, ensuring that the content is both relevant and accessible to learners from different backgrounds.

Our framework's approach is designed with a dual focus, incorporating general LLM prompting principles, which apply universally across multiple contexts, and application-specific (pedagogical) principles tailored to particular training scenarios such as those involving ADAS and AV. The general principles aim to guide the creation of effective, clear, focused, and contextually appropriate prompts. The application-specific principles enable the customisation of instructional content to meet the unique needs of learners. This dual approach ensures that ChatGPT delivers informative, engaging, personalised, and directly relevant training to the specific learning objectives.

In applying these principles to AV driver training, we equipped ChatGPT with a detailed user manual for an AV, instructing it to use this information to conduct an interactive, conversation-based training session. This method focuses on personalised learning experiences and ensures that instruction is based solely on the provided materials, thereby avoiding external information that could lead to inconsistencies or inaccuracies. The framework offers a versatile methodology for developing instructional content for ChatGPT by articulating a clear distinction between general and application-specific principles. This approach facilitates the creation of training programs that are effective, engaging, and tailored to the diverse needs and backgrounds of learners. To optimise the instructional effectiveness of ChatGPT in training scenarios, such as ADAS and AV driver training, we introduce a framework distinguishing between general LLM prompting principles and application-specific (pedagogical) principles. This distinction clarifies the underlying rationale of each principle and its relevance to specific applications, including ADAS and AV training. To study our framework's practical application and effectiveness, we present a detailed demonstration of its implementation

in training drivers for AV. This illustrates the adaptability and precision of our guiding principles and showcases our approach's tangible benefits. This practical demonstration serves as a robust proof of concept, reinforcing the applicability of our framework across various training domains and specifically highlighting its efficacy in preparing drivers for the complexities of navigating AV.

General LLM Prompting Principles

These foundational principles are applicable across a wide range of applications and are crucial for creating effective ChatGPT prompts:

- i. **Goal and scene setting:** Begin the conversation with ChatGPT by clearly defining the goals, approaches, and conditions. The rationale behind setting the scene and defining goals is to provide a clear context that guides the LLM to respond appropriately to the user's needs within the specified scenario. When the LLM is aware of the scene, it can customise its language, tone, and content to match the specific requirements of the task, ensuring that the training is relevant and effective. A well-defined prompt significantly reduces the likelihood of misunderstandings, which are critical to avoid when the LLM is the primary source of instruction. The design rationale is consistent with [43, 154].

Below is a practical example that demonstrates how to apply our framework's principles, explicitly focusing on the initial goal and scene setting with ChatGPT.

"Hello ChatGPT, in my next message, I will provide you with the contents of a user manual for an autonomous vehicle (AV). This manual provides information on how to operate an AV in a simulated environment. Instead of asking the participants to read the manual by themselves, you will digest the contents and then use an interactive, conversation-based approach to teach the participants how to drive the AV and operate various ADAS functions." [Approaches]

"Your goal is to ensure that participants feel confident and capable of using the ADAS functions and operating the AV safely and efficiently after they have received this training from you." [Goals]

"Please ensure that the guide and instructions that you provide to the participants are solely based on the information provided within the given manual and do not draw from general knowledge or external resources." [Conditions]

Following this, the contents of the user manual were pasted to ChatGPT via the prompt.

In this study, we provided ChatGPT with all the contents in the user manual, which include clear definitions of the operation procedures and limitations of each ADAS function. We instructed ChatGPT not to pull information from external resources to maintain clarity and consistency. This approach ensures all participants receive the same level of detail about each function, avoiding the situation where ChatGPT might generate false information, thus reducing potential confusion.

- ii. **Providing structured instruction to ChatGPT:** Consistency is crucial in helping ChatGPT understand and respond appropriately. This could apply to various scenarios, like instructing different operations in a factory or explaining other administrative procedures in an office setting. Framing information consistently can significantly improve the clarity of the response and facilitate the learning process. To ensure this, we have established a standard structure for presenting instructions to ChatGPT. For every ADAS function, we begin with its function name, then provide a brief description, specify its physical location on the experiment setup, verbally describe its symbol, and finally, with its activation and deactivation procedures. This consistent approach facilitates more effective prompt responses. Since our user manual has already been written in a systemic structure, no special instructions are needed in our experiment.
- iii. **Reiterate objectives and conditions to ChatGPT regularly:** It is vital to remind ChatGPT regularly each time a session is initiated or resumed to adhere strictly to the instructions provided in the manual or training materials. It could be critical because of the conversational memory and the maximum token limitations in LLM-based tools. This practice could make ChatGPT less likely to divert or start utilising information from external or generic sources and thus ensure context retention and adherence to specified guidelines throughout the interaction. Regular reinforcement of these guidelines helps maintain the focus and accuracy of the ChatGPT responses. Such reiteration can compensate for the absence of a sustained conversational memory [52] in AI systems such as ChatGPT, facilitating more accurate and contextually relevant responses. However, our study did not encounter this issue, as each participant received training through separate prompts. Furthermore, the user manual was concise and short (approximately 1100 words); therefore, we did not reach ChatGPT's maximum token capacity.

Tokenisation and chunking, specifically in the context of Open-AI's GPT-3 and GPT-4, refers to breaking down the input and output into smaller pieces known as tokens. A token could be as small as one character or a word (for example, the letter 'a' could be a token, and the word 'apple' could also be a token). When there's a long dialogue with many back-and-forth conversations, ChatGPT can hit its maximum token limit (e.g., GPT maximum is 4097 tokens) [53]. When this limit is reached, some of the earlier parts of the conversation may be cut off, resulting in the model losing the context or instructions provided at the beginning. To address this issue, important instructions should be reiterated regularly to ensure the model continues following them. This is especially crucial when the instructions involve adhering strictly to a particular set of guidelines or utilising specific terms. For instance, in this study, they are the names and symbols of the ADAS functions.

Application-Specific (Pedagogical) Principles

- iv. **Personalised responses:** Customise your instructions and questions to match your task's specific requirements and your audience's characteristics. Personalised responses ensure that the instruction is comprehensible to participants from diverse backgrounds, thereby enhancing their understanding and application of the information provided. For instance, considering our participants are from diverse backgrounds, we guided ChatGPT to keep its instructions simple and clear. This makes it easier for participants to understand and follow. However, if the participating groups have relevant professional knowledge, using well-known technical terminologies and jargon can ease understanding and make the conversation more engaging. Highlighting or bolding key points may help draw participants' attention to crucial information. For example, in our experiment, we instructed ChatGPT: *"Your audience is the general public; please use simple words and highlight keywords in your response to participants' inquiries."*
- v. **Proactive knowledge checking on learners:** One can train ChatGPT to respond to a query with the corresponding answer plus a relevant follow-up question to check a learner's understanding. Using follow-up questions is one of the best methods to reinforce learning through retrieval practice [155]. This can be achieved by instructing ChatGPT to pose a follow-up question to the participant after its response. For instance, in this study, we

instructed ChatGPT that if a participant asks how to activate any ADAS function, it should display the steps and then ask a follow-up question. The following instruction was given to ChatGPT: *“After you respond to the participant’s question, please ask a follow-up question similar to the one which is mentioned below”. “Do you understand how to use this function, or would you like me to explain it to you again”?*

- vi. **Phrasing output format:** One can instruct ChatGPT to present its responses in various formats, such as bullet points, paragraphs, or tables. Utilising bullet points is particularly effective for presenting sequential instructions in a clear and easy-to-follow manner. For instance, in this study, we guided ChatGPT to rephrase its output by instructing it to; *“Please use bullet points to list the steps for activating or deactivating any function”.*

5.4.1. Assessment of ChatGPT’s Response Accuracy and Sample Interactions

In our experimental setup, we designed a unique user manual, approximately 1,100 words in length, detailing the location and function of each ADAS feature. Three functions were located on the steering wheel and two on the shifter module. This specificity ensured that ChatGPT relied solely on the information provided, which helped maintain the accuracy of its responses. Throughout the experiment, we did not observe any false responses generated by ChatGPT.

However, ChatGPT does have limitations, especially after pauses in interaction or when initiating a new session due to the sustained conversational memory issue in ChatGPT [52], as well as when reaching the maximum token limit [53], which may result in irrelevant or incorrect information. These limitations are further compounded when requesting real-time or very recent information [42]. We did not observe any false or incorrect responses generated by ChatGPT during our experiment, confirming its accuracy within our specific parameters. The study’s limitation lies in the brief nature of our user manual (which was around 1100 words in length), which does not adequately represent the complexities of processing larger documents. Such complexities could challenge ChatGPT’s token capacity, potentially increasing the risk of generating inaccurate or invented information.

Furthermore, for more robust analysis, it would be ideal to implement systematic procedures to identify false, biased, or incomplete information automatically. For future work, it is also important to investigate how LLMs manage more lengthy documents and whether this affects the tendency to

invent information. Future research should also be conducted to validate ChatGPT's performance in terms of accuracy and reliability. This aspect has also been highlighted by [156] as a key area for future research.

Participants learned about all the ADAS and AV functions available in the simulated AV through interactions with ChatGPT. To provide a comprehensive overview of ChatGPT's performance, we present five examples of questions asked by the learners, distributed across three types of inquiries. These include two questions relating to functions available in our AV simulator, two queries about non-existing functions, and one more complex, conditional inquiry illustrated through a specific scenario-based question. The rationale was to assess whether ChatGPT can provide valid answers across various scenarios without inventing information. In all cases, the responses from ChatGPT were accurate, demonstrating the model's capability to handle direct inquiries (the functions available in simulated AV as shown in Fig. 5.5 and Fig. 5.6) and hypothetical scenarios (functions not available in AV as demonstrated in Fig. 5.7 and Fig. 5.8), and complex, conditional inquiries (as illustrated in the new Fig 5.9) effectively.

Additionally, we observed that, on average, participants asked seven questions while interacting with ChatGPT. The responses from ChatGPT, averaging approximately 124 words per question, were concise yet comprehensive, making it easier for participants to understand and engage with the content. Furthermore, we analysed the total length of participant's communication with ChatGPT, including the provided AV user manual, instructions and questions asked by the participants, which amounted to approximately 2520 words. This quantitative analysis is instrumental in highlighting the level of engagement, depth of user interactions and the efficacy of ChatGPT's responses.

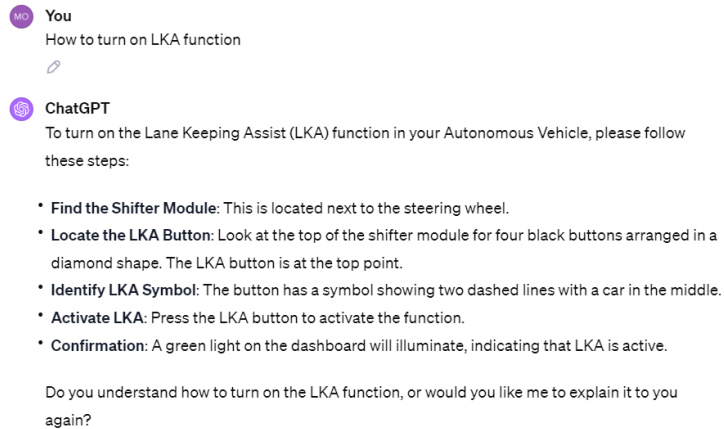


Figure 5.5: Screenshot of a learner-1 inquiring about an existing function in the simulator.

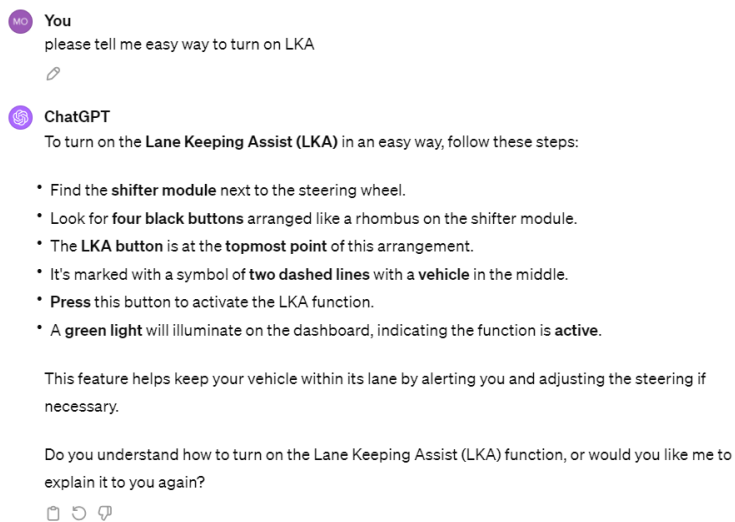


Figure 5.6: Screenshot of a learner-2 inquiring about an existing function in the simulator.

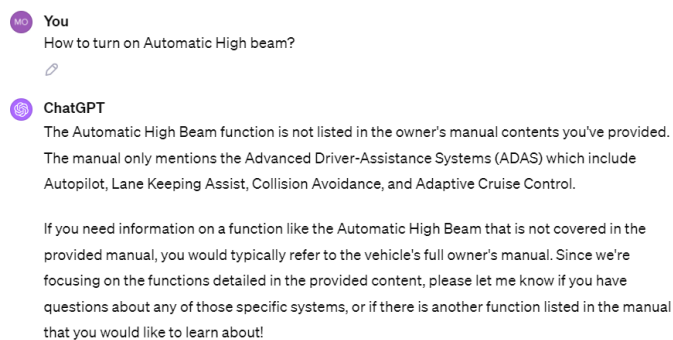


Figure 5.7: Screenshot of a learner-1 inquiring about a non-existing function in the simulator.

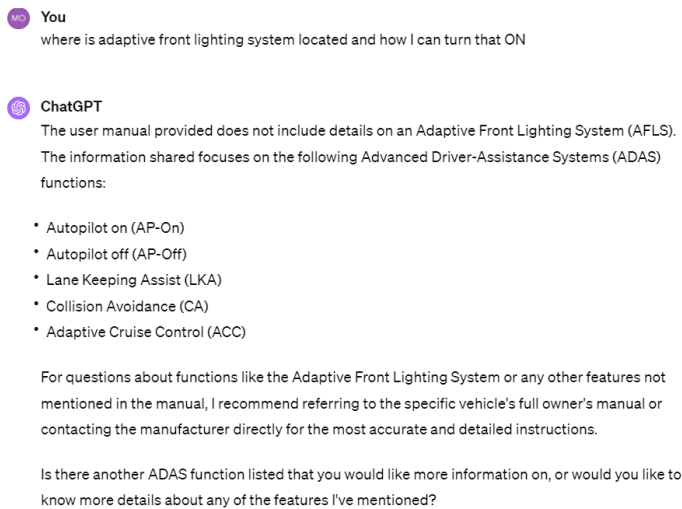


Figure 5.8: Screenshot of a learner-2 inquiring about a non-existing function in the simulator.

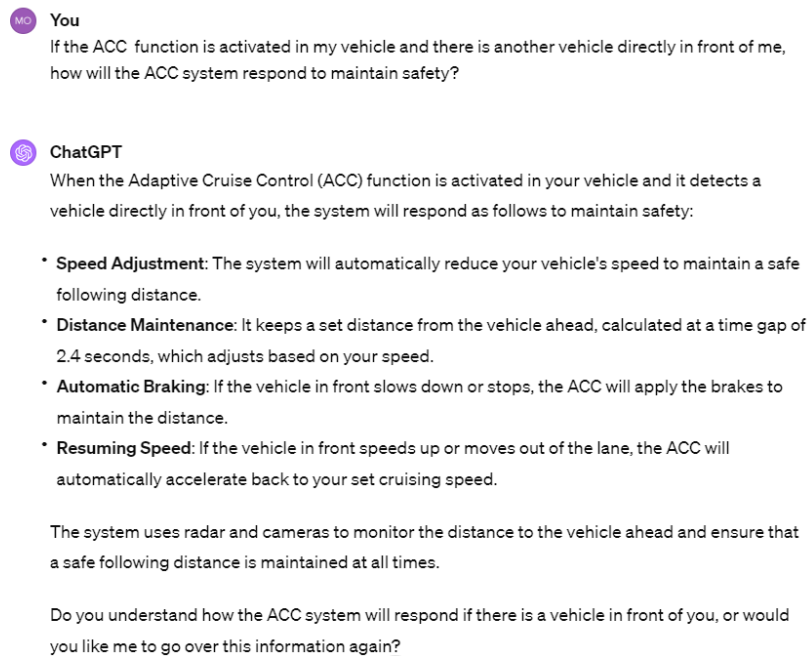


Figure 5.9: Screenshot of a learner inquiring about a complex, conditional inquiry of an existing function in the simulator.

5.4.2. Preparing the Learners

The effectiveness of using ChatGPT as a teaching aid in education and training depends on educators or trainers providing clear guidance to their learners on how to interact with and learn from the system. In this work, our training approach is based on a well-structured preparation process, which

was delivered through a short introduction video to ensure consistency in the instruction mode. The following steps outline our methodology for preparing the video:

Defining Learning Objectives: In the beginning section, we set clear learning goals, emphasising the participants' comprehension of ADAS functions. This step provides a clear target for the training and ensures learners know what they are expected to learn.

Introducing ADAS Context and Vocabulary: The next section in the instructional video presents the experimental context and introduces key ADAS features within a simulated AV environment to engage the participants. Simultaneously, it provides essential ADAS-related technical terms such as AP, ACC, LKA, and CA, equipping learners with the language needed for accurate discussions with ChatGPT. This ensures that the discussions are technically relevant.

An Interaction Kickstarting Example: The final section of the video guides learners on initiating interaction with ChatGPT. It suggests starting the conversation with specific queries like, *"I am a new user, please tell me what functions are available in the AV?"* to ensure that learners engage in informed discussions about the functions and their operational processes.

5.5. Results and Analysis

In our study, we aimed to investigate the significance and impact of different training approaches for end-users of ADAS and autonomous driving functionalities within an AV. Participants interacted with the AV system within a simulated environment, using either an innovative training method facilitated by ChatGPT or a conventional method comprising video demonstrations and user manual instructions. A critical element of ChatGPT-based training was developing a set of principles designed to optimise the effectiveness of ChatGPT in generating prompts and yielding better learning outcomes. Performance metrics included participants' accuracies, represented by the percentage of correct actions executed, and response latencies, calculated as the time difference between when the audio instruction was issued and when the correct ADAS function was activated or deactivated.

5.5.1. Accuracy Analysis

The results of this study are derived from the comparative analysis of two groups: a conventional learning group of 46 participants and a ChatGPT group of 40 participants, a total of 86 participants.

Participants were trained on five ADAS functions: AP-On, AP-Off, LKA, CA, and ACC, using their respective training methods.

According to the data presented in Table 5.5, those trained with ChatGPT demonstrated a comprehensive understanding of all five functions, achieving accuracies ranging from 80% to 100%. It was observed that both ChatGPT and video-based learners reached 100% accuracy in identifying and using the AP-On and AP-Off functions, irrespective of training methods and their driving experience levels. The prominent placement of these AP functions at the top of the steering wheel likely contributed to the uniform high accuracy rates.

The physical placement of each ADAS function is also an important factor in understanding the study's outcomes. LKA and ACC functions were situated on the shifter module, whereas the CA system's control was accessible on the side of the steering wheel. Compared to the AP-On and AP-Off functions at the top of the steering wheel, the less intuitive placement of the LKA, CA, and ACC functions likely contributed to the varied accuracy rates across these functions. The ChatGPT group outperformed the video-based group for the LKA function by achieving a 92% accuracy rate compared to the latter's 71 %. It is worth noting that the video-based group did not have data for CA and ACC, mimicking a real-world scenario where not all ADAS functions are demonstrated by the sales agent. The ChatGPT group demonstrated a 95% accuracy rate for the CA function, compared to the 73% observed in the user manual group. Likewise, ACC function accuracy was 80% for ChatGPT learners, compared to 58% for those who used the user manual.

To thoroughly evaluate the effectiveness of the training methods, a statistical analysis was conducted using the Pearson Chi-square method. This analysis revealed significant differences in learning outcomes between the groups for several ADAS functions. Specifically, the p-values obtained are 0.014 for the LKA function, 0.008 for the ACC function, and 0.034 for the CA function. Given that these p-values are below the threshold of 0.05, it can be concluded that the observed differences in learning outcomes are statistically significant. This evidence supports the superior effectiveness of the ChatGPT-based training approach, particularly for ADAS functions where operational complexity and non-intuitive physical placement may hinder learning. The slightly lower accuracy for the ACC function across both learning methods could be due to its more complex operation, requiring sequential button presses to engage and set speed, emulating manufacturers' real-time vehicle control systems [113, 157].

Table 5.5: Participants' average accuracies after being trained using different methods.

Group-Division w.r.t training method	No. of participants in each group	AP-On response accuracy in %	AP-Off response accuracy in %	LKA response accuracy in %	CA response accuracy in %	ACC response accuracy in %
ChatGPT-based learning Group	40	100	100	92	95	80
Conventional learning group	46	100	100	71	73	58

5.5.1.1. Analysis based on the Driving Experience

Driver experience is categorised as either a novice driver (one to three years), an intermediate driver (four to six years), or an experienced driver (over six years). This is consistent with [148, 149]. Our study investigated the relationship between driving experience and participants' proficiency with ADAS. This is outlined in Tables 5.6 and 5.7 for the conventional and ChatGPT learning groups, respectively. Our findings concur with [31] that increased driving experience corresponds to improved performance in activating ADAS functions.

It is clear from Table 5.6 that novice drivers in the conventional group had lower accuracy rates (57% for LKA and CA and 43% for ACC), reflecting a learning curve associated with these functions. As experience increased, so did proficiency: intermediate drivers (four to six years) showed improved accuracy (70% for LKA and CA and 54% for ACC), and experienced drivers (over six years) reached higher accuracy levels (84% for LKA, 89% for CA, and 74% for ACC).

For the ChatGPT group (Table 5.7), novice drivers started with higher accuracy rates of 84% for LKA and CA and 77% for ACC. This trend of improvement was more noticeable as drivers gained experience, with intermediate drivers reaching 90% in LKA and 100% in CA and experienced drivers achieving a perfect 100% accuracy in both LKA and CA, with ACC at 88%. The ACC function showed slightly lower accuracy in both learning methods. This may be because it is more complex to use, requiring sequential button presses to activate and set the speed, which mirrors the vehicle control system of the actual vehicle [113, 157].

The observed differences in performance between the conventional and ChatGPT groups indicate that the method of instruction may influence how drivers learn and apply ADAS and AV functions.

The ChatGPT group's results suggest that this educational methodology may offer a more effective foundation for understanding these complex systems, particularly for novice drivers. These insights support the integration of advanced instructional tools, such as ChatGPT, into driver training programs. This integration aims to enhance the utilisation of ADAS and potentially improve road safety for drivers at all experience levels.

Table 5.6: Conventional group participant's response accuracy w.r.t their driving experience

Driving experience	AP-On response accuracy in %	AP-Off response accuracy in %	LKA response accuracy in %	CA response accuracy in %	ACC response accuracy in %
Novice driver (1-3 years)	100	100	57	57	43
Intermediate driver (4-6 years)	100	100	70	70	54
Experienced driver (Above 6 years)	100	100	84	89	74

Table 5.7: ChatGPT group participant's response accuracy w.r.t their driving experience

Driving experience	AP-On response accuracy in %	AP-Off response accuracy in %	LKA response accuracy in %	CA response accuracy in %	ACC response accuracy in %
Novice driver (1-3 years)	100	100	84	84	77
Intermediate driver (4-6 years)	100	100	90	100	82
Experienced driver (Above 6 years)	100	100	100	100	88

5.5.1.2. Analysis based on the frequency of use of the ADAS function

In a comprehensive analysis of driver engagement with ADAS functions, we observed a consistent positive relationship between the real-life frequency of ADAS utilisation and the accuracy of

participant responses. Analysing the conventional training group more closely, individuals who had never/occasionally used ADAS functions (in their real life) demonstrated initial competencies at 53% for LKA, 60% for CA, and 46% for ACC. Intermittent users of ADAS in their daily driving have experienced noticeable improvements. The accuracy rates for LKA and CA have increased to 76%, while the accuracy for ACC has risen to 58%. Regular ADAS users within this group improved further, achieving 85% precision in LKA and CA and 71% in ACC, as demonstrated in Table 5.8.

Participants in the ChatGPT educational group who never/occasionally used ADAS functions demonstrated high accuracy rates, 76% for LKA, 84% for CA, and 69% for ACC. The intermittent users showed swift learning, with perfect scores of 100% for LKA and CA and an impressive 86% for ACC. Regular users in this group upheld these high precision levels, consistently scoring 100% for LKA and CA and improving to 91% for ACC, as demonstrated in Table 5.9.

Our findings concur with the research of [31], supporting the concept that consistent real-world utilisation of ADAS is associated with enhanced driver performance. The comparison between conventional training and the ChatGPT-based approach highlights the potential influence of teaching methods on understanding and implementing ADAS features. Participants who were trained using ChatGPT demonstrated enhanced proficiency, suggesting that this method might provide benefits for learning complex automotive technologies. This is especially evident among new and occasional users, where the ChatGPT group's performance was relatively higher than the conventional group, suggesting ChatGPT offers a potentially more intuitive learning experience. These results support the integration of educational tools like ChatGPT into driver training curriculums, with the potential to increase the effectiveness of ADAS usage and improve road safety for drivers of different experience levels.

Table 5.8: Conventional group participant's response accuracy w.r.t their ADAS frequency of use

Groups- division w.r.t ADAS function frequency of use	AP-On response accuracy in %	AP-Off response accuracy in %	LKA response accuracy in %	CA response accuracy in %	ACC response accuracy in %
Never/Occasionally used	100	100	53	60	46
Intermittent user	100	100	76	76	58
Regular user	100	100	85	85	71

Table 5.9: ChatGPT group Participant's Response accuracy w.r.t their ADAS frequency of use

Groups- division w.r.t ADAS function frequency of use	AP-On response accuracy in %	AP-Off response accuracy in %	LKA response accuracy in %	CA response accuracy in %	ACC response accuracy in %
Never/Occasionally used	100	100	76	84	69
Intermittent user	100	100	100	100	86
Regular user	100	100	100	100	91

5.5.1.3. Analysis based on the participants' familiarity with ChatGPT

Table 5.10 demonstrates a positive correlation between the frequency of ChatGPT usage and the improvement in ADAS function response accuracy. Those who use ChatGPT regularly achieved 100% accuracy in performing most functions, with a 92% performance in ACC. This suggests that consistent interaction with LLM-based tools can enhance one's ability to learn effectively.

Intermittent engagement with ChatGPT demonstrated improved performance outcomes. This is evidenced by a 100% accuracy rate in AP-On and AP-Off responses and a high degree of proficiency

of 95% in LKA and CA functionalities. These findings suggest that periodic interactions with LLM-based platforms can substantially augment learning processes.

Individuals with minimal or no previous interaction with ChatGPT showed comparatively lower yet acceptable proficiency in activating ADAS functions. Specifically, in LKA and ACC functionalities, they achieved 75% and 63% accuracy, respectively, which, although satisfactory, are less than those observed in individuals who engaged with ChatGPT intermittently or regularly, as demonstrated in Table 5.10. These functions, located on the shifter module and not as intuitively accessible as those on the steering wheel, presented a steeper learning curve for these users. The challenge mentioned by participants, which we collected through feedback discussed in Section 5.3, reflects their initial struggles with navigating ChatGPT. They recommended incorporating visual aids in ChatGPT-focused training to help new users easily find and use ADAS functions. However, most participants reflected that ChatGPT training is engaging, enjoyable, and interactive. They appreciated that ChatGPT simplifies the information retrieval process, allowing users to concentrate more on learning and understanding ADAS and AV functions. This observation resonates well with [43, 158, 159]. A noticeable correlation exists between regular ChatGPT usage and proficiency in handling ADAS and AV functions, emphasising the importance of integrating LLM-based tools in training for complex technological systems.

Table 5.10: ChatGPT group participants' response accuracy w.r.t their familiarity with ChatGPT

Groups- division w.r.t their familiarity with ChatGPT	ChatGPT learning group: No of participants in the group	AP-On response accuracy in %	AP-Off response accuracy in %	LKA response accuracy in %	CA response accuracy in %	ACC response accuracy in %
Never/Occasionally used	8	100	100	75	87	63
Intermittent user	20	100	100	95	95	85
Regular user	12	100	100	100	100	92

5.5.2. Reaction Time Analysis

Data from the two groups, one trained with a conventional method and the other with ChatGPT was initially subjected to a normality analysis using Shapiro-Wilk's and Anderson-Darling's test. This preliminary analysis was performed to guide our decision in choosing the appropriate statistical test, parametric or non-parametric, depending on the normality of the data.

For the group that underwent training via the conventional methods, covering all ADAS functions (AP-On, AP-Off, LKA, CA, and ACC), it was verified through Shapiro-Wilk's and Anderson-Darling's tests that the collected data did not conform to a normal distribution. In contrast, data from participants trained through the ChatGPT system showed mixed results. The data adhered to a normal distribution for certain ADAS functions, namely AP-On and AP-Off, as confirmed by Shapiro-Wilk's and Anderson-Darling's tests. However, the data did not follow the normal distribution for the remaining functions, LKA, CA, and ACC. Consequently, conventional statistical measurements that assume normality, such as the analysis of variance (ANOVA) test, did not apply to this dataset. Given these observations, we determined that non-parametric testing was the appropriate statistical method for our analysis. We utilised the Mann-Whitney U test, a recommended non-parametric test for comparing two unrelated samples when the data are not normally distributed [150]. Therefore, the interpretation of our results was approached with due consideration of these analytical choices and the inherent attributes of the collected data.

The key performance indicator examined in this section is the reaction time required by the participants to activate/deactivate ADAS functions correctly. This metric was selected to evaluate and compare the efficacy of the two different instructional methodologies in imparting the participants' critical operational skills related to ADAS.

5.5.2.1. AP-On and AP-Off functions

The box plots in Figure 5.10 and Figure 5.11 demonstrate unique patterns between participants trained using conventional methods and those trained using ChatGPT. It is clear from Figure 10 (AP-On) group 1 that participants trained with the conventional method had a median response time recorded as 3.25 seconds. The span of response times for this group ranged from 2.30 to 6.00

seconds. This relatively wide range suggests a dispersion in data points, reflecting variability in the time taken by participants to press the correct button. The Standard Deviation (SD) for this group was calculated to be 0.92 seconds, underlining a higher variability in response times.

Conversely, participants in group 2, trained using ChatGPT, demonstrated a lower median response time of 2.51 seconds. Data from this group was more narrowly distributed, ranging from 1.80 to 3.32 seconds, and there was a significantly lower SD of 0.44 seconds. This tight range reflects greater consistency among participants, suggesting that they were quicker and more uniform in selecting the correct button. Outliers for both groups are marked with the “+” symbols on the plot.

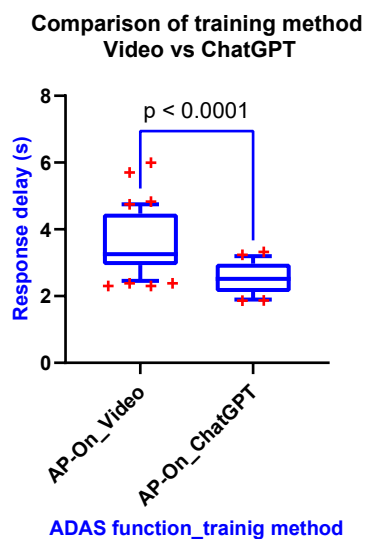


Figure 5.10: AP-Off reaction time comparison between Video vs ChatGPT training methods. “+” shows the outliers.

In Figure 5.11 (AP-Off condition), the median response time for the conventional method group increased slightly to 3.30 seconds, with responses scattered between 2.31 and 6.20 seconds. The SD for this group was calculated as 0.93 seconds. In contrast, the ChatGPT group in the AP-Off condition posted a median response time of 2.59 seconds. Their responses, ranging from 1.86 to 3.63 seconds and displaying a notably lower SD of 0.46 seconds, exhibited a tighter data clustering, indicative of more uniform performance among this cohort. Outliers for both groups are marked with the “+” symbols on the plot.

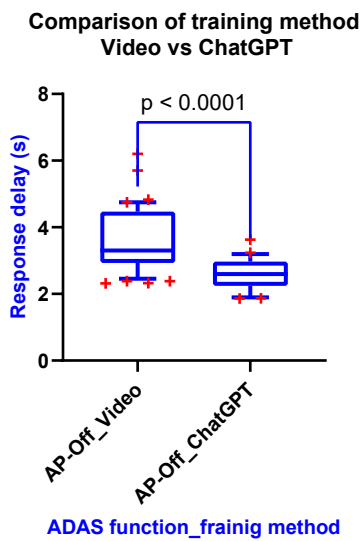


Figure 5.11: AP-Off reaction time comparison between Video vs ChatGPT training methods. “+” shows the outliers.

As presented in Table 5.5, the average accuracy for both AP-On and AP-Off conditions was recorded at 100% for all participants, irrespective of the training methods. However, the lower deviation and shorter response times of the ChatGPT groups suggest a better learning outcome of this approach.

A statistical comparison between the groups, employing the Mann-Whitney U test, was conducted for both AP-On and AP-Off conditions. The tests revealed statistically significant differences ($p < 0.05$) between the two groups in both situations. Participants trained via ChatGPT consistently selected the correct response more rapidly than their conventionally trained counterparts. The highly significant p-value of less than 0.0001 provides compelling evidence for rejecting the null hypothesis, thereby validating the observed training advantage of the ChatGPT method in both autopilot conditions.

5.5.2.2. LKA function

The box plots in Figure 5.12 demonstrate response times (in activating the LKA function) between participants trained through conventional methods and those trained using ChatGPT. It's noteworthy that, unlike the AP-On and AP-Off functions, the LKA function is situated on the shifter module instead of the steering wheel, a factor that may influence response times.

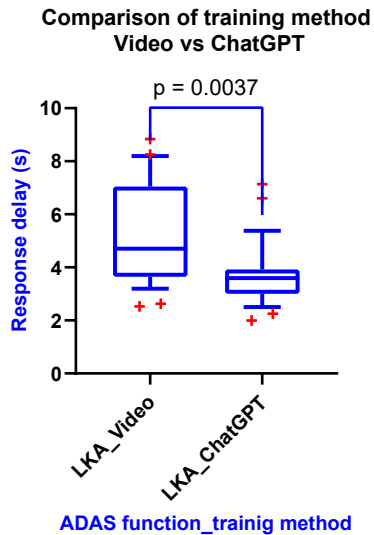


Figure 5.12: LKA reaction time comparison between Video vs ChatGPT training methods. “+” shows the outliers.

It can be observed from Figure 5.12 that participants trained using conventional methods showed a median response time of 4.70 seconds. The response times for this group ranged from 2.52 to 8.84 seconds, with an SD of 1.92 seconds, highlighting a broad distribution in the time participants took to activate the correct function, indicating a wider variation in individual performance. In contrast, the group trained via ChatGPT had a lower median response time of 3.59 seconds. Their response times were tightly packed, ranging from 1.99 to 6.60 seconds, with a lower SD of 1.03 seconds. This data suggests a higher level of consistency among the participants in this group, implying they were both quicker and steadier in selecting the correct command on the shifter module.

Statistical comparisons between the two groups using the Mann-Whitney U test highlighted a significant difference in the response times ($p < 0.05$). The test produced a p-value of 0.0037, demonstrating strong evidence that the response times between the two groups were not the same. This underscores the superior efficiency of the ChatGPT training method, which showed significantly shorter response times than the conventional training method, even when interacting with the ADAS function located on the shifter module, which generally can take longer to reach.

5.5.2.3. CA function

The box plots in Figure 13 show the variability and central tendency of response times across both groups in activating the CA function. The group trained using the user manual recorded a median activation time of 4.40 seconds. In contrast, the ChatGPT-trained group demonstrated a faster

median activation time of 3.18 seconds. This difference again suggests a quicker response time for participants trained through the ChatGPT model.

Analysing the spread of data offers additional insights. The group trained with the user manual showed a wide range of response times, extending from 2.02 to 8.54 seconds, with an SD of 1.64. This signifies a substantial variation in individual performance within this group. Conversely, the group trained with ChatGPT showed a more consistent range of response times, stretching from 2.10 to 6.40 seconds, and a lower SD of 0.98. This tighter spread suggests a greater consistency in performance among these participants.

The Mann-Whitney U test was used to ascertain the statistical significance of the differences observed. The resulting p-value was 0.0002, substantially below the commonly accepted significance level of 0.05. This indicates that the difference in median activation times between the two groups is statistically significant. These findings suggest that ChatGPT-based interactive training could lead to faster activation of the CA function than instruction methods relying on conventional user manuals.

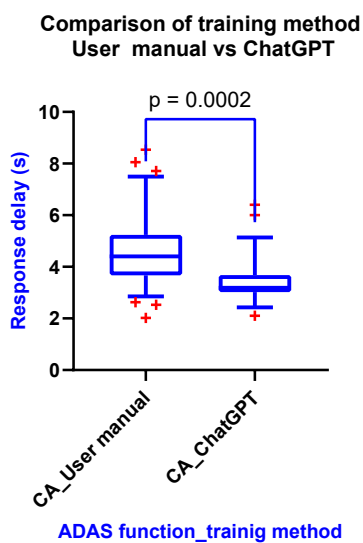


Figure 5.13: CA reaction time comparison between User Manual vs ChatGPT training methods. “+” shows the outliers.

5.5.2.4. ACC function

The study further investigates the effectiveness of two distinct training approaches in instructing participants to operate the ACC function. This operation is slightly more complex, requiring the activation of two buttons: one to engage the ACC and a second to set the speed. This configuration

was designed to emulate real-time vehicle control systems in models like those outlined in the [113, 157].

The group trained via the conventional user manual displayed a median activation time of 6.95 seconds, with individual values ranging from 3.94 to 9.05 seconds. The SD for this group was 1.35, reflecting a substantial variation in individual performances. On the other hand, participants trained through the ChatGPT-based interactive user manual showed a notably more efficient performance. The median activation time for this group was significantly reduced to 4.91 seconds. Furthermore, the range of response times in this group was narrower, spanning from 3.04 to 7.90 seconds, with a lower SD of 1.007. This suggests a greater level of consistency in performance among the ChatGPT-trained participants.

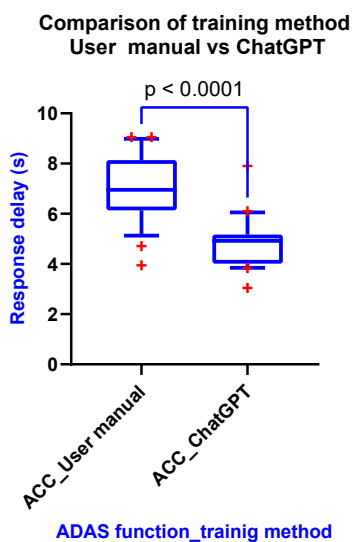


Figure 5.14: ACC reaction time comparison between User Manual vs ChatGPT training methods. "+" shows the outliers.

A Mann-Whitney U test was performed to statistically assess the observed differences in median activation times between the two groups. As displayed in Figure 14, the resulting p-value was less than 0.0001, significantly lower than the standard threshold of 0.05, indicating a statistically significant difference. These findings suggest that ChatGPT-based interactive user manual training is more effective in teaching participants to promptly activate the ACC function than the conventional user manual approach.

5.6. Discussion

5.6.1. Training Methods

This study aimed to determine whether the interactive and personalised instruction offered by ChatGPT could enhance learning efficiency and accuracy compared to conventional methods. Our key findings revealed that ChatGPT-based training led to faster activation times, increased consistency, and high accuracy across all examined ADAS functions.

The conventional learning process for ADAS functions is indeed diverse, involving demonstrations by sales agents at dealerships [18], video-based instruction [3, 17], and self-study through the vehicle's user manual [29, 30]. However, these methods have their limitations. For instance, due to time constraints and the complexity of ADAS features, dealership sales agents might not fully cover all available functionalities, leading to a knowledge gap [31]. Furthermore, these agents may lack the necessary expertise to adequately explain the operation of ADAS [32], further widening this informational gap. Additionally, user manuals, although detailed, often require a high level of existing knowledge and considerable time to be effectively used [33]. This is further compounded by the lack of interactive learning experience [34], which limits the effectiveness of these manuals.

A potential explanation for the superior performance of the ChatGPT-based training could be attributed to the interactive, responsive, and engaging nature of chatbot-based learning. Prior research [43, 160] has suggested that applying LLMs, such as ChatGPT, enhances the educational experience by providing personalised instructions and immediate feedback. This feature potentially creates a more engaging learning environment that could facilitate quicker mastery of tasks and improved consistency in task performance.

The observed improvements of participants in learning outcomes can be further explained as follows: The interactive nature of chatbot learning infuses an element of gamification into the educational process. As [161] suggests, this aspect makes learning more enjoyable, thereby increasing user engagement. The 'game-like' interaction keeps the learners interested, providing a more dynamic, participatory, and effective learning experience. It is, therefore, reasonable to infer that the introduction of chatbots like ChatGPT into the learning paradigm has the potential to enrich the learning experience and motivate learners by making the process more enjoyable and engaging.

The growing complexity of ADAS demands innovative approaches to user education. Our study's findings suggest that AI-assisted tools like ChatGPT could potentially fill this gap, offering a more comprehensive and efficient learning experience than conventional video-based training or user manuals. The ChatGPT training methodology in our study demonstrated a high degree of accuracy across all tested ADAS functions.

The results presented in Table 5.5 reflect the significant benefits of using ChatGPT for learning ADAS functions. Notably, the ChatGPT group achieved an impressive accuracy range of 80% to 100% across all functions. Even when confronted with the complexities of ACC, the accuracy remained at a substantial 80%. In comparing these two instructional methodologies, the ChatGPT-based training consistently led to shorter median activation times and tighter data dispersion, indicating that participants were quicker and more consistent in activating the desired functions. Further research should be conducted to investigate the optimum number of training sessions to achieve even higher accuracy and to shorten the reaction time further in activating the ADAS or AV functions.

These results support the continued development and application of AI-based training methods like ChatGPT. However, further research is needed to corroborate these findings and explore the potential of such training methods across a broader spectrum of tasks and contexts. With technological advances and the increasing complexity of vehicle control systems, the need for effective and efficient training methods is evident. The findings of this study indicate that ChatGPT-based training could be a promising approach in this respect.

While promising, these findings should be interpreted cautiously, as other hidden factors could have influenced the outcomes. Future research should strive to replicate these findings across different settings and with larger participant samples to establish the generalisability of these results. The potential for extending the application of such AI-based training to other vehicle systems or even beyond the automotive industry is also worth investigating.

5.6.2. The Framework for Preparing a ChatGPT Prompt.

In this work, we used a customised, ChatGPT-based interactive training platform to educate participants about the ADAS functions of a simulated AV. The principles we followed in this context ensured an effective training program and illustrated the broader potential of LLM across different industries.

The essence of effective training with ChatGPT lies in the level of specificity and context provided. We aimed to equip participants with comprehensive knowledge about each ADAS function. For instance, we detailed the concept, purpose, location, symbol, and procedure for activating/deactivating different functions. This meticulous approach eliminated any assumption of prior knowledge on the part of participants and reduced the possibility of confusion.

Ensuring the consistency of instruction delivery is another fundamental aspect of our method. We established a standard format for presenting information on ADAS functions. Additionally, we incorporated a proactive knowledge check mechanism into our training framework. This mechanism provides necessary information and asks a follow-up question to assess participant comprehension, thereby promoting iterative learning.

The constraints of AI systems, such as the absence of sustained memory in ChatGPT, necessitate regular reiteration of key instructions throughout user interactions [52] and have been incorporated into the framework into some best practices, which ensure more accurate and contextually relevant responses. Furthermore, setting an output format personalised to each individual's learning experience can optimise the training efficacy.

Prompt engineers play a crucial role in enhancing user experiences with LLMs by guiding learners on how to effectively phrase and frame their questions or requests to utilise the LLM's full potential. We found that treating interactions with ChatGPT as two-way conversations, providing long-form questions, or sharing contextual narratives resulted in more precise and relevant responses.

Overall, our training method using a ChatGPT-based platform led to enhanced performance among participants compared to those trained using conventional methods. This was validated by the accuracy of activating the ADAS functions and reaction time. This suggests that the customised and interactive approach adopted for ChatGPT-based training was more effective in teaching participants about ADAS functions. Our study thus shows the immense potential of LLM-augmented approach training methods and their viability across various industries.

5.6.3. Subjective Opinions of Participants

The objective outcomes presented in Section 4 indicated improved accuracy and reaction times when using ChatGPT for ADAS training. To complement these findings, we collected the participants'

subjective views to understand their personal experiences with the training process. These subjective experiences are crucial for interpreting the objective results, offering insights into the specific features of the ChatGPT training, which participants found beneficial. By examining these perspectives, we aim to uncover the factors contributing to their improved performance.

At the end of each participant's training, we collected their subjective opinions about the learning process with ChatGPT. Our study's qualitative analysis suggests that 90% of these opinions were positive. Participants highlighted ChatGPT as a dynamic and engaging environment ideal for learning ADAS functionalities. Notably, the system's interactivity and tailored approach were well-received, with learners appreciating the information's concise and direct delivery. Well-structured responses with highlighted keywords expedited the learning process and made it more enjoyable, integrating elements of gamification and motivation into the educational experience. These observed benefits are consistent with the studies [43, 158, 159, 162]. However, a minority of participants, approximately 8%, reported initial difficulties in interaction and a preference for additional visual aids to assist in the learning process. Despite these minor challenges, introducing the LLM into the training process positively influenced learning outcomes. In future research, we aim to conduct quantitative analysis, such as the NASA Task Load Index (NASA-TLX), to substantiate further the correlation between participant motivation, engagement, cognitive load, and learning efficiency. A key focus could be on examining the cognitive load during the learning process, particularly how AI-based learning compares to conventional methods in this aspect. A comparative study could also explore whether adopting LLM-based training tools can result in a reduced mental workload, thereby leading to improved performance and understanding of complex ADAS functionalities. Furthermore, conducting a study to determine if learning with LLM-augmented methodologies leads to quicker learning than conventional methods would be a valuable extension of our research.

Selected feedback from participants is as follows:

Positive feedback:

1. "Using ChatGPT has significantly enhanced my learning experience. It's particularly helpful for quick, direct responses to specific queries. The instructions given by ChatGPT were easy for me to follow and to locate the buttons. I like the output format in bullet points, and it allows me to step by step follow the instructions".

2. "Interacting with ChatGPT is enjoyable and makes learning easier because you can get direct answers to your questions. For example, when I asked about activating the Autopilot feature in a car, ChatGPT promptly directed me to its button on the steering wheel. This immediate assistance saves time and makes learning efficient, enjoyable, and fun. I like that you do not need to search for the relevant information, ChatGPT does it for you".

Negative feedback:

1. "I found the learning process with ChatGPT a bit confusing since it didn't provide any visuals for the ADAS functions. I had to read the text and figure out the location of the button. It would be easier if ChatGPT included images of the ADAS functions".
2. "I had a bit of trouble learning with ChatGPT because it didn't show me any pictures of the ADAS buttons; I only got written explanations. In my opinion, images can help to make learning easier. Overall, I like learning with ChatGPT as I do not need to read all the details. You ask ChatGPT, and it filters for you".

The participants' reflections on using ChatGPT for ADAS training reveal its potential to enhance the educational experience. Their positive feedback underscores ChatGPT's intuitive interface and engaging interaction, suggesting that the AI-facilitated training could lead to more effective learning outcomes by making the process engaging and interactive. Additionally, the feedback highlights ChatGPT's role in streamlining the learning process by efficiently offloading the information retrieval task. ChatGPT enables participants to focus more on memorising and understanding the placement and use of ADAS features, as illustrated by participants' feedback for direct, step-by-step instructions and immediate, relevant answers.

However, the feedback also highlights areas for improvement, such as the need for visual aids to complement textual explanations. Recognising this, future research should consider the integration of multimedia into ChatGPT's reply. This advancement could potentially revolutionise the training experience by providing customised visual prompts alongside textual explanations, thereby accommodating the diverse audience for learning.

5.6.4. Extending LLM-augmented Training to other Industries

The previous sections demonstrated the framework's effectiveness in preparing a ChatGPT prompt to train drivers on ADAS and AV functions. Nonetheless, the proposed framework has broader applicability beyond the AV industry. For instance, it can be used in the manufacturing sector to facilitate the assembly of complex machinery. Consider an ordinary assembly task involving a jet engine in an aviation manufacturing setting. In this context, the proposed framework can effectively utilise a ChatGPT prompt to train technicians or engineers in assembling/maintaining a jet engine.

Goal and scene setting: Start the interaction with ChatGPT by outlining the goals, methods, and conditions:

"Hello ChatGPT, in my next message, I will provide you with the contents of a detailed operational manual for assembling a jet engine. This manual includes comprehensive instructions on how to assemble the jet engine in a manufacturing setting. Instead of having the technical staff read the manual, you will interpret the contents and use an interactive, dialogue-based method to guide them through the assembly process." [Approaches]

"Your goal is to ensure that the technicians or engineers can navigate through the complex assembly process of the jet engine efficiently, confidently, and safely after they have received this training." [Goals]

"Ensure that the guidance and instructions you provide to the technical staff are solely based on the specifics within the given manual and do not draw from generic knowledge or external resources." [Conditions]

Then, the contents of the operational manual (in this case, the Jet engine assembly guideline) are provided to ChatGPT via the prompt. This approach assures that all participants receive consistent and accurate information about each task, avoiding potential confusion.

Personalise responses: The prompt engineer should customise the instructions and questions to match the audience's characteristics and task. In this scenario, where qualified engineers and technicians assemble a jet engine, it is important to instruct ChatGPT to use technical language and terminologies specific to the industry. The instructions should be detailed and

precise, facilitating easy understanding and follow-through for the employees involved in the assembly process.

Providing structured instruction to ChatGPT: Consistency is vital to helping ChatGPT to understand and respond correctly. It would be good to follow the standard process and procedure for each assembly step to tell ChatGPT about each part's assembly guidelines. For example, start with each part/instrument name, provide a detailed description, specify its physical location on the jet engine, describe any symbols or tools related to it, and finally, explain its execution procedure.

Proactive knowledge checking on learners: Train ChatGPT to answer a query with the corresponding answer and a relevant follow-up question to check the understanding of the engineers or technicians. For example, if a technician asks how to install a particular part, ChatGPT should present the steps and then ask a follow-up question: "Do you know where the part is located and what tools you need to use, or would you like me to explain in further detail?"

Reiterate objectives and conditions to ChatGPT regularly: It's crucial to remind ChatGPT every few prompts to adhere strictly to the instructions in the manual. This maintains the focus and accuracy of ChatGPT responses. Regular reinforcement of these guidelines is important, especially when a new conversation with ChatGPT is initiated or resumed after a pause.

Phrasing output format: Guide ChatGPT in presenting its responses in various formats as needed. For instance, instruct ChatGPT to *"use detailed paragraphs for the description of each assembly step, use bullet points to list the steps for executing each step, and if the engineer or technician specifically requests information in a table format, provide it accordingly."*

5.7. Chapter Summary

This chapter compared conventional driver education methods versus an innovative LLM-augmented training approach for AV technologies. As vehicular technology advances, effective driver training becomes crucial for the safe and efficient use of advanced systems like ADAS and AVs. This study

evaluated conventional paper and video-based training against LLM-based training using ChatGPT. Participants were divided into two groups: one trained using conventional methods and the other using ChatGPT. The study focused on essential metrics such as reaction times and accuracy in activating ADAS and AV functions. The results showed that the ChatGPT-trained group demonstrated significant improvements, including shorter activation times, higher consistency, and enhanced accuracy across all functions examined.

The chapter introduced a strategic framework to maximise the potential of LLMs like ChatGPT in driver education, allowing for customised interactions and targeted learning experiences. Additionally, it presented a comprehensive framework for preparing ChatGPT prompts, ensuring that instructional content is relevant and accessible to learners from diverse backgrounds. This framework includes general LLM prompting principles and application-specific pedagogical principles, facilitating the creation of effective, engaging, and personalised training programs. Empirical evidence supports the effectiveness of LLM-augmented training, suggesting broader implications for future educational practices in technologically advanced systems. This analysis lays the groundwork for integrating artificial intelligence into educational strategies, providing insights into its scalable applications across various learning environments.

Methodologically, a driving simulator created a realistic training environment, and statistical analyses ensured a diverse and balanced participant sample. A comprehensive framework for ChatGPT prompts was introduced, ensuring relevant and accessible content tailored to learners' needs. The interactive nature of ChatGPT-based learning was a key factor in its effectiveness, leading to superior learning outcomes compared to conventional methods. The chapter concludes that LLM-augmented training significantly enhances driver education for ADAS and AVs. The findings support further development and application of AI-based training methods, emphasising the need for innovative and efficient training strategies in response to evolving vehicular technologies.

Chapter 6: Conclusion and Future Work

6.1. Conclusion

This thesis has extensively analysed ADAS and AV functions, focusing on the importance of standardised terminology, effective training, and innovative instructional methods. The research encompasses three main areas: the need for standardised terminology and operational transparency, the impact of training on driver proficiency, and the efficacy of LLM-augmented instructional methods.

Standardising nomenclature and operational transparency

The research underscores the critical need for standardising ADAS functions' nomenclature and operational transparency. The study revealed a significant lack of consensus among car manufacturers regarding naming conventions for ADAS functionalities, leading to driver confusion and potential safety risks. This inconsistency, also noted by the American Automobile Association, highlights the urgency for unified naming conventions and transparent operational procedures. Recommendations from this research include:

- ♦ **Unified naming conventions for AI/ADAS functions:** Local policymakers should establish rules for standardising AI/ADAS nomenclature, which automakers should adhere to, ensuring country-specific compliance.
- ♦ **Uniform activation/deactivation processes:** Further research should determine the most effective activation and deactivation processes for ADAS functions. Based on the research outcomes, manufacturers should design the activation/deactivation processes for the ADAS functions accordingly.

- ♦ **Consistent design philosophy:** Manufacturers should design intuitive warning mechanisms and vehicle behaviours based on research into the effectiveness of different message types on driver alertness.
- ♦ **Develop and design quantifiable operating conditions and system limitations:** Depending on the AI technology used and sensor types deployed by different manufacturers, quantifiable operating conditions should be disclosed to the buyers so that users can make a well-informed buying decision.
- ♦ **Develop clear and straightforward calibration and maintenance processes for all the sensors:** Automakers should design standard calibration processes and sensor maintenance guidelines. They should develop standardised monitoring and diagnostic mechanisms for evaluating sensor health conditions.
- ♦ **Designing of safety systems with uniform operating speed:** Local rule regulators and automakers should define the baseline operating conditions of common ADAS functions. Automakers should then design their systems and functions to fulfil those requirements.
- ♦ **Develop a better instruction-sharing and training process:** Research should be conducted to study the effective and best possible training structure for AV drivers. Based on the research outcomes, local licensing authorities can design the training and licensing framework for AV drivers.

These guidelines aim to assist road transport regulatory bodies in developing comprehensive policies, thereby aiding the automotive industry in deploying safer and more effective ADAS technologies. By providing clear information and standardised procedures, both manufacturers and consumers can benefit from improved understanding and adoption of ADAS functions, reducing the risk of accidents.

Impact of training on driver proficiency

This study also aims to provide significant insights into the role of training and driving practice opportunities in enhancing drivers' proficiency in utilising ADAS and AV functions and improving vehicle control in diverse driving scenarios. Below are some of the key findings of this study.

- ♦ Training significantly improves drivers' performance in interacting with ADAS functions while driving. Notably, the most significant improvements can be achieved after two training sessions, emphasising the importance of providing adequate instructional resources and practice opportunities. Training and practice sessions enhance drivers' accuracy in

operating ADAS functions while reducing their reaction times. This improvement positively affects vehicle trajectory and reduces the risk of crashes.

- ◆ Both novice and experienced drivers reap substantial advantages from training sessions. For novice drivers, substantial improvements in accuracy, reaction time, and vehicle control are observed after two training sessions. Experienced drivers, too, derive considerable benefits from training, as it enables them to rapidly refine their mental models, equipping them with the capacity to manage complex driving scenarios and employ ADAS functions with increased efficiency. The findings underscore the fact that even experienced drivers may initially face challenges when encountering novel ADAS functions.
- ◆ Vehicle trajectory analysis reveals that training helps to minimise serpentine driving behaviour and improve vehicle control, thereby reducing the risk of crashes and enhancing overall driving safety.
- ◆ The RMSE values for vehicle lateral movement among all participants showed a considerable decrease across the three trials, emphasising the importance of ongoing training and practice in maximising the safety benefits and efficient use of ADAS functions in real-world driving situations.

Simultaneously, policy suggestions should be made based on research outcomes. Transport industry regulatory authorities should establish policies that delineate the responsibility and liability between manufacturers and end-users of ADAS functions, contingent on the levels of training provided and received. Consumers should be well-informed regarding the consequences, obligations, and liabilities of not participating in or completing the training. Additionally, transport industry regulatory authorities must establish rules to ensure that official-brand and independent car dealers are proficient in major, if not all, ADAS and AV functions in modern vehicles. Clear rules and regulations should be defined to force car manufacturers, dealers, and rental companies to guarantee adequate training for end-users upon receiving their vehicles. End-users must be well-informed about the implications of responsibility and liability when using any ADAS and/or autonomous driving functions without completing the respective training modules.

By addressing these future research directions and policy suggestions, the field can work towards a more comprehensive understanding of ADAS and AV training and its implications on driving performance, safety, and overall user experience. This will ultimately contribute to the

development of more effective training programs and better-informed policies for the safety and widespread adoption of ADAS and AV technologies.

Efficacy of LLM-Augmented Instructional Methods

This research has yielded significant insights into the effectiveness of conventional instructional methods versus LLM-augmented approaches for teaching ADAS functions. The study demonstrated that utilising an LLM-based tool, such as ChatGPT, enhances accuracy and efficiency in user education concerning advanced vehicular systems. The implications of these findings are substantial for the automotive and transportation industry. ChatGPT has the potential to bridge the existing knowledge gap regarding ADAS functions, facilitating a higher adoption rate. This novel instructional method may also reduce incidents caused by misusing or misunderstanding these complex systems, ultimately contributing to improved road safety.

For educators, the findings emphasise the transformative potential of LLMs in user education, suggesting a future where educational strategies incorporate these advanced tools. The effectiveness of ChatGPT highlighted in this research advocates for the inclusion of LLM-based instructional tools in future guidelines and training programs for ADAS and other complex vehicular systems. The lack of comprehensive regulation or standardised platforms for ADAS function training highlights the need for these findings to initiate discussions to develop such frameworks.

In conclusion, the comparative study on LLM-augmented instructional methods highlights their potential to enhance driver education and safety in the context of ADAS technologies. By integrating these advanced tools into educational strategies and regulatory frameworks, the automotive industry can ensure more effective training and safer utilization of ADAS functions, fostering broader acceptance and better-informed usage among drivers. This comprehensive approach, addressing nomenclature standardization, training efficacy, and innovative instructional methods, paves the way for a safer and more proficient integration of ADAS and AV technologies into everyday driving.

6.2. Limitations and Future Work

Based on the findings from this research, several key areas for future work have been identified, focusing on further refinement and proposing general design guidelines for effective ADAS and AV training. This section also addresses the current study's limitations, providing a foundation for the suggested future research directions.

- ♦ **Integration of real-time feedback and AI-assisted coaching:** Explore the benefits of incorporating real-time feedback systems, LLM-based coaching [163], and gamification concepts [164] into training programs to enhance the learning experience and driving performance.
- ♦ **ADAS and AV training efficacy:** Evaluate the effectiveness of LLM-based learning in understanding ADAS and AV functionalities using knowledge assessments and the NASA-TLX to measure comprehension and cognitive load, comparing results to conventional paper-based methods [163].
- ♦ **Extending LLM-Augmented training to other industries:** Explore the applicability of LLM-based training in various industries, such as manufacturing, to facilitate complex tasks like the assembly and maintenance of machinery, demonstrating the framework's versatility beyond the automotive industry [163].
- ♦ **Policy development:** Develop policies that clearly delineate the responsibilities and liabilities of manufacturers and end-users based on training levels. Ensure that car dealers, rental companies, and end-users are adequately informed and proficient in ADAS functions.

Future research can contribute to a more comprehensive understanding of ADAS and AV training by addressing these areas, ultimately enhancing driving safety and user experience. The exploration of long-term retention and optimal training frequency, integration of real-time feedback and AI-assisted coaching, evaluation of LLM-based learning effectiveness, and extension of LLM-augmented training to other industries will provide valuable insights. These advancements will inform the development of better-informed policies and training programs, supporting effective deployment and adoption of these technologies. As a result, we can anticipate safer and more efficient roadways, benefiting both users and the broader community.

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Appendices

Appendix – A: ChatGPT Interaction Samples

In this appendix, we present samples of participants' interactions with ChatGPT to give readers an understanding of the nature and length of these communications while learning about ADAS and AV functions. For detailed analysis and metrics regarding these interactions, please refer to Chapter 5, Section 5.4.

A-1: ChatGPT Interaction Sample-1

This sample showcases the interaction between a participant and ChatGPT, demonstrating the conversational flow and depth of information provided while learning about ADAS and AV functions.



You

Hello ChatGPT, in my next message, I will provide you with the contents of a user manual for an autonomous vehicle (AV). This manual provides information on how to operate an AV in a simulated environment. Instead of asking the participants to read the manual by themselves, you will digest the contents, and then use an interactive, conversation-based approach to teach the participants how to drive the AV and operate various ADAS functions." [Approaches] "Your goal is to ensure that participants feel confident and capable of using the ADAS functions and operating the AV safely and efficiently after they have received this training from you." [Goals] "Please ensure that the guide and instructions that you provide to the participants are solely based on the information provided within the given manual and do not draw from general knowledge or external resources." [Conditions]

ChatGPT

ChatGPT

Absolutely, I'm ready to assist with that. Once you provide the contents of the user manual for the autonomous vehicle (AV), I will use that

You

WELCOME to ChatGPT based Autonomous Vehicle interactive training! Owner's Manual Welcome to the ChatGPT based Autonomous Vehicle interactive training platform where you will learn how to operate an Autonomous Vehicle (AV) in a simulated environment, specifically focusing on the utilisation of the Advanced Driver-Assistance Systems (ADAS). This guide will walk you through each step, providing clear instructions on how to use each ADAS feature available in the car. Driving seat environment: When you're in the driver's seat, you'll find the steering wheel in front of you with the shifter module next to it (on the right side), and pedals underneath. On your screen, the front (bonnet) of your AV is displayed in red. Please note when any of the ADAS function is activated, a green illuminated light on the screen will indicate that the function is active. ADAS and AV functions available in the car: There are five functions available in this car, • Autopilot on (AP-on) • Autopilot off (AP-off), • Lane keeping Assist (LKA) • Collision Avoidance (CA) • Adaptive Cruise Control (ACC) Below is a guide on how to operate each of these functions. 1. Autopilot (AP) Function Description: Auto pilot function consist of below safety features. When this function is ON system automatically controls all the manoeuvres of the vehicle. Please note that it does not replace the driver. It is the driver's responsibility to stay alert, drive safely, and be always in control of the vehicle. When Autopilot function is off in that case you need to manually drive the vehicle. • Adaptive Cruise Control • Lane Keeping Assist • Collision Avoidance • Blind Spot Assist How to Turn on Autopilot • The AutoPilot On button is located on the right side of the steering wheel. • There are three buttons on the right side of the steering wheel. • The AutoPilot button is the topmost button among these. It's marked with the label 'Autopilot on'. Press this button to activate the function. • When this function is activated, a green light will illuminate on the dashboard. How to Turn off AP • The AutoPilot Off (AP-off) button is located on the left side of the steering wheel. • There are three buttons on the left side of the steering wheel. Press this button to deactivate the autopilot function. • The AutoPilot Off button is the topmost button among these. It's marked with the label 'Autopilot off' 2. Lane Keeping Assist (LKA) function Description: The Lane Keeping Assist alerts when the vehicle is about to run off the road or exit the lane. If required system will make necessary manoeuvres to keep the vehicle in the desired lane. This camera-based system warns starting at a minimum speed. The minimum speed is country-specific and is displayed in the menu for the intelligent Safety systems. Warnings are issued by means of a steering wheel vibration. The severity of the steering wheel vibration can be adjusted. The system does not provide a warning if the turn signal is set before leaving the lane. The system thus helps keep the vehicle in the lane. How to turn on LKA • The LKA button is located on the shifter module. • The shifter module's top houses four black buttons arranged like the points of a rhombus, and the LKA button is at the topmost point. • The symbol for LKA is represented as two dashed lines with a vehicle in the middle. Press this button to activate the LKA function. • When this function is activated, a green light will illuminate on the dashboard. 3. Collision Avoidance (CA) Function Description: The system may prevent some accidents. In the event of an accident, the system may reduce impact speed. The system sounds a warning before an imminent collision and activates brakes independently, if needed. Depending on the equipment version, the system is controlled by the following sensors: • Camera in the area of the interior mirror. • Radar sensor in the front bumper. The system issues a two-phase warning of a possible risk of collision with vehicles at speeds above approx. 10 km/h. The timing of warnings may vary with the current driving situation. With the vehicle approaching another vehicle intentionally, the approach control warning and braking is delayed in order to avoid false system reactions. How to turn on CA • On the steering wheel, there are two knobs/indicators, one on the left side and one on the right side. • The knob on the left side of the steering wheel is used to turn on and off the CA system. • The symbol for the Collision Avoidance button depicts two cars next to each other with a few lines in between. 4. Adaptive Cruise Control (ACC) Function: Description:

Using this system, a desired speed and a distance to a vehicle ahead can be adjusted using the buttons on the steering wheel. The system maintains the desired speed on clear roads. For this purpose, the vehicle accelerates or brakes automatically. If a vehicle is driving ahead of you, the system adjusts the speed of your vehicle so that the set distance to the vehicle ahead is maintained. The speed is adjusted as far as the given situation allows. When the system is on it maintains the distance of 2.4 sec to vehicle Infront of you depending on the speed. A radar sensor is located in the front bumper and a camera on the interior mirror to detect vehicles driving ahead of you. Depending on the vehicle setting, the cruise control settings may change under certain conditions. For instance, acceleration can change depending on the driving mode. The distance can be adjusted in several steps. For safety reasons, it depends on the respective speed. If the vehicle ahead of you brakes to a halt, and then proceeds to drive again within a brief period, the system can detect this within the given system limits. How to turn on ACC • The ACC button is located on the shifter module. • The ACC function is controlled by the first two of the four red buttons located towards the bottom of the shifter module from the left. First, press the leftmost button, which is marked with a speedometer symbol. Then, press the second button, labelled 'SET'. • A green light will illuminate on the dashboard when ACC is activated. Warnings and system limitations Many factors can impact the performance of Autopilot components, causing them to be unable to function as intended. These include (but are not limited to): • Poor visibility (due to heavy rain, snow, fog, etc.). • Bright light (due to oncoming headlights, direct sunlight, etc.). • Damage or obstructions caused by mud, ice, snow, etc. • Interference or obstruction by object(s) mounted onto the vehicle (such as a bike rack). Obstruction caused by applying excessive paint or adhesive products (such as wraps, stickers, rubber coating, etc.) onto the vehicle. • Narrow or winding roads. • A damaged or misaligned bumper. • Interference from other equipment that generates ultrasonic waves. • Extremely hot or cold temperatures. No need to respond at this stage, I will provide you more instructions in my next message.

ChatGPT

ChatGPT

Understood! I've reviewed the content you've provided from the owner's manual. I'm ready to use this information

MO

You

Please strictly follow the guidelines when you respond to participants questions. (1) Your audience is the general public; please use simple words and highlight keywords in your response to participants' inquiries. (2) Please use bullet points to list the steps for activating or deactivating any function. (3) After you respond to the participant's question, please ask the follow-up question, similar to the one which is mentioned below. "Do you understand how to use this function, or would you like me to explain it to you again? From next message participant will ask you question, please provide the training as per the above guidelines and provided user manual.

ChatGPT

ChatGPT

Understood. I will follow the provided guidelines and use the information from the user manual to respond to participants' questions, using simple language, highlighting keywords, and listing steps with bullet points. After responding, I'll ask if they need further clarification. I'm ready for the participant's questions.

MO

You

I am new user, please tell me what are the functions available in the AV?

ChatGPT

ChatGPT

Welcome to your Autonomous Vehicle (AV) training! Here are the functions available in your AV:

- **Autopilot on (AP-on):** This function takes control of the vehicle's maneuvers but requires you to stay alert and in control.
- **Autopilot off (AP-off):** You use this to manually drive the vehicle when Autopilot is not active.
- **Lane Keeping Assist (LKA):** It helps keep the vehicle within the lane boundaries and alerts you if the car starts to drift.
- **Collision Avoidance (CA):** It warns you of potential collisions and can apply the brakes if necessary.
- **Adaptive Cruise Control (ACC):** Maintains a set speed and distance from the car in front of you, adjusting speed as needed.

Do you understand how to use these functions, or would you like me to explain any of them to you again?

MO

You

How to activate Autopilot function?

ChatGPT

ChatGPT

Activating the Autopilot function on your Autonomous Vehicle (AV) is straightforward. Here are the steps:

- **Locate the Autopilot Button:** This is on the right side of the steering wheel.
- **Identify the Button:** Look for the topmost button among the three buttons on the right side of the steering wheel. It's labeled 'Autopilot on'.
- **Activate:** Press the 'Autopilot on' button to activate the function.
- **Confirmation:** A green light will illuminate on the dashboard to indicate that Autopilot is active.

Remember, even with Autopilot active, it's essential to stay alert and maintain control of the vehicle at all times.

Do you understand how to activate the Autopilot function, or would you like me to explain it to you again?

MO

You

How to turn on LKA function

ChatGPT

ChatGPT

To turn on the Lane Keeping Assist (LKA) function in your Autonomous Vehicle, please follow these steps:

- **Find the Shifter Module:** This is located next to the steering wheel.
- **Locate the LKA Button:** Look at the top of the shifter module for four black buttons arranged in a diamond shape. The LKA button is at the top point.
- **Identify LKA Symbol:** The button has a symbol showing two dashed lines with a car in the middle.
- **Activate LKA:** Press the LKA button to activate the function.
- **Confirmation:** A green light on the dashboard will illuminate, indicating that LKA is active.

Do you understand how to turn on the LKA function, or would you like me to explain it to you again?

MO

You

What is purpose of CA function, and how to turn on the function

ChatGPT

ChatGPT

The purpose of the **Collision Avoidance (CA) function** is to help prevent accidents or reduce the severity of a collision. Here's how it works and how to activate it:

- **Warning System:** It sounds a warning if a potential collision is detected.
- **Automatic Braking:** If necessary, it automatically applies the brakes to avoid or mitigate a collision.

To turn on the Collision Avoidance function, please follow these steps:

- **Locate the Knobs:** On the steering wheel, find the two knobs/indicators.
- **Use the Left Knob:** The knob on the left side of the steering wheel controls the CA system.
- **Identify the CA Symbol:** The symbol for CA shows two cars with lines in between, representing a potential collision.
- **Activate CA:** Turn the knob to the CA symbol to activate the system.
- **Confirmation:** Look for a green light on the dashboard to confirm that CA is activated.

Do you understand the purpose of the CA function and how to turn it on, or would you like me to explain it to you again?

MO

You

How to turn on Automatic High beam?

ChatGPT

ChatGPT

The Automatic High Beam function is not listed in the owner's manual contents you've provided. The manual only mentions the Advanced Driver-Assistance Systems (ADAS) which include Autopilot, Lane Keeping Assist, Collision Avoidance, and Adaptive Cruise Control.

If you need information on a function like the Automatic High Beam that is not covered in the provided manual, you would typically refer to the vehicle's full owner's manual. Since we're focusing on the functions detailed in the provided content, please let me know if you have questions about any of those specific systems, or if there is another function listed in the manual that you would like to learn about!

MO

You

How to activate ACC function

ChatGPT

ChatGPT

To activate the Adaptive Cruise Control (ACC) function on your Autonomous Vehicle, please follow these steps:

- **Find the Shifter Module:** This is located next to the steering wheel.
- **Locate the ACC Buttons:** Look towards the bottom of the shifter module for the red buttons.
- **Identify the ACC Buttons:** The ACC is controlled by the first two red buttons from the left.
 - The first button has a speedometer symbol.
 - The second button is labeled 'SET'.
- **Activate ACC:**
 - Press the button with the speedometer symbol to turn on the cruise control feature.
 - Then press the 'SET' button to activate Adaptive Cruise Control.
- **Confirmation:** A green light will illuminate on the dashboard indicating that ACC is active.

Do you understand how to activate the ACC function, or would you like me to explain it to you again?

MO

You

If the ACC function is activated in my vehicle and there is another vehicle directly in front of me, how will the ACC system respond to maintain safety?

ChatGPT

ChatGPT

When the Adaptive Cruise Control (ACC) function is activated in your vehicle and it detects a vehicle directly in front of you, the system will respond as follows to maintain safety:

- **Speed Adjustment:** The system will automatically reduce your vehicle's speed to maintain a safe following distance.

- **Distance Maintenance:** It keeps a set distance from the vehicle ahead, calculated at a time gap of 2.4 seconds, which adjusts based on your speed.
- **Automatic Braking:** If the vehicle in front slows down or stops, the ACC will apply the brakes to maintain the distance.
- **Resuming Speed:** If the vehicle in front speeds up or moves out of the lane, the ACC will automatically accelerate back to your set cruising speed.

The system uses radar and cameras to monitor the distance to the vehicle ahead and ensure that a safe following distance is maintained at all times.

Do you understand how the ACC system will respond if there is a vehicle in front of you, or would you like me to go over this information again?

MO

You

Can you please help me to locate AP-off function?

ChatGPT

ChatGPT

Certainly! Here's how you can locate the Autopilot Off (AP-off) function in your vehicle:

- **Steering Wheel:** Look at the steering wheel in front of you.
- **Left Side:** Focus on the left side of the steering wheel.
- **Buttons:** Find three buttons on this side.
- **Topmost Button:** The AP-off function is the topmost button among these three.
- **Label:** This button is labeled 'Autopilot off'.

Press this button when you wish to deactivate the Autopilot function and take full manual control of the vehicle.

Do you understand how to locate the AP-off function, or would you like me to explain it to you again?

A-2: ChatGPT Interaction Sample-2

This segment features an interaction with ChatGPT, illustrating the system's consistent reliability in providing detailed descriptions of ADAS and AV functions in response to a participant's question, as outlined in the user manual.

You

Hello ChatGPT, in my next message, I will provide you with the contents of a user manual for an autonomous vehicle (AV). This manual provides information on how to operate an AV in a simulated environment. Instead of asking the participants to read the manual by themselves, you will digest the contents, and then use an interactive, conversation-based approach to teach the participants how to drive the AV and operate various ADAS functions." [Approaches] "Your goal is to ensure that participants feel confident and capable of using the ADAS functions and operating the AV safely and efficiently after they have received this training from you." [Goals] "Please ensure that the guide and instructions that you provide to the participants are solely based on the information provided within the given manual and do not draw from general knowledge or external resources." [Conditions]

ChatGPT

ChatGPT

I'm ready to assist with this task. Please provide the contents of the user manual for the autonomous vehicle (AV), and I'll help you develop an interactive, conversation

You

WELCOME to ChatGPT based Autonomous Vehicle interactive training! Owner's Manual Welcome to the ChatGPT based Autonomous Vehicle interactive training platform where you will learn how to operate an Autonomous Vehicle (AV) in a simulated environment, specifically focusing on the utilisation of the Advanced Driver-Assistance Systems (ADAS). This guide will walk you through each step, providing clear instructions on how to use each ADAS feature available in the car. Driving seat environment: When you're in the driver's seat, you'll find the steering wheel in front of you with the shifter module next to it (on the right side), and pedals underneath. On your screen, the front (bonnet) of your AV is displayed in red. Please note when any of the ADAS function is activated, a green illuminated light on the screen will indicate that the function is active. ADAS and AV functions available in the car: There are five functions available in this car, • Autopilot on (AP-On) • Autopilot off (AP-Off), • Lane keeping Assist (LKA) • Collision Avoidance (CA) • Adaptive Cruise Control (ACC) Below is a guide on how to operate each of these functions. 1. Autopilot (AP) Function Description: Auto pilot function consist of below safety features. When this function is ON system automatically controls all the manoeuvres of the vehicle. Please note that it does not replace the driver. It is the driver's responsibility to stay alert, drive safely, and be always in control of the vehicle. When Autopilot function is off in that case you need to manually drive the vehicle. • Adaptive Cruise Control • Lane Keeping Assist • Collision Avoidance • Blind Spot Assist How to Turn on Autopilot • The AutoPilot On button is located on the right side of the steering wheel. • There are three buttons on the right side of the steering wheel. • The AutoPilot button is the topmost button among these. It's marked with the label 'Autopilot on'. Press this button to activate the function. • When this function is activated, a green light will illuminate on the dashboard. How to Turn off AP • The AutoPilot Off (AP-off) button is located on the left side of the steering wheel. • There are three buttons on the left side of the steering wheel. Press this button to deactivate the autopilot function. • The AutoPilot Off button is the topmost button among these. It's marked

with the label 'Autopilot off' 2. Lane Keeping Assist (LKA) function Description: The Lane Keeping Assist alerts when the vehicle is about to run off the road or exit the lane. If required system will make necessary manoeuvres to keep the vehicle in the desired lane. This camera-based system warns starting at a minimum speed. The minimum speed is country-specific and is displayed in the menu for the intelligent Safety systems. Warnings are issued by means of a steering wheel vibration. The severity of the steering wheel vibration can be adjusted. The system does not provide a warning if the turn signal is set before leaving the lane. The system thus helps keep the vehicle in the lane. How to turn on LKA • The LKA button is located on the shifter module. • The shifter module's top houses four black buttons arranged like the points of a rhombus, and the LKA button is at the topmost point. • The symbol for LKA is represented as two dashed lines with a vehicle in the middle. Press this button to activate the LKA function. • When this function is activated, a green light will illuminate on the dashboard. 3. Collision Avoidance (CA) Function Description: The system may prevent some accidents. In the event of an accident, the system may reduce impact speed. The system sounds a warning before an imminent collision and activates brakes independently, if needed. Depending on the equipment version, the system is controlled by the following sensors: • Camera in the area of the interior mirror. • Radar sensor in the front bumper. The system issues a two-phase warning of a possible risk of collision with vehicles at speeds above approx. 10 km/h. The timing of warnings may vary with the current driving situation. With the vehicle approaching another vehicle intentionally, the approach control warning and braking is delayed in order to avoid false system reactions. How to turn on CA • On the steering wheel, there are two knobs/indicators, one on the left side and one on the right side. • The knob on the left side of the steering wheel is used to turn on and off the CA system. • The symbol for the Collision Avoidance button depicts two cars next to each other with a few lines in between. 4. Adaptive Cruise Control (ACC) Function: Description: Using this system, a desired speed and a distance to a vehicle ahead can be adjusted using the buttons on the steering wheel. The system maintains the desired speed on clear roads. For this purpose, the vehicle accelerates or brakes automatically. If a vehicle is driving ahead of you, the system adjusts the speed of your vehicle so that the set distance to the vehicle ahead is maintained. The speed is adjusted as far as the given situation allows. When the system is on it maintains the distance of 2.4 sec to vehicle Infront of you depending on the speed. A radar sensor is located in the front bumper and a camera on the interior mirror to detect vehicles driving ahead of you. Depending on the vehicle setting, the cruise control settings may change under certain conditions. For instance, acceleration can change depending on the driving mode. The distance can be adjusted in several steps. For safety reasons, it depends on the respective speed. If the vehicle ahead of you brakes to a halt, and then proceeds to drive again within a brief period, the system can detect this within the given system limits. When the Adaptive Cruise Control (ACC) function is activated in your vehicle and it detects a vehicle directly in front of you, the system will respond as follows to maintain safety: • Speed Adjustment: The system will automatically reduce your vehicle's speed to maintain a safe following distance. • Distance Maintenance: It keeps a set distance from the vehicle ahead, calculated at a time gap of 2.4 seconds, which adjusts based on your speed. • Automatic Braking: If the vehicle in front slows down or stops, the ACC will apply the brakes to maintain the distance. • Resuming Speed: If the vehicle in front speeds up or moves out of the lane, the ACC will automatically accelerate back to your set cruising speed. The system uses radar and cameras to monitor the distance to the vehicle ahead and ensure that a safe following distance is maintained at all times. How to turn on ACC • The ACC button is located on the shifter module. • The ACC function is controlled by the first two of the four red buttons located towards the bottom of the shifter module from the left. First, press the leftmost button, which is marked with a speedometer symbol. Then, press the second button, labelled 'SET'. • A green light will illuminate on the dashboard when ACC is activated. Warnings and system limitations Many factors can impact the performance of Autopilot components, causing them to be unable to function as intended. These

include (but are not limited to): • Poor visibility (due to heavy rain, snow, fog, etc.). • Bright light (due to oncoming headlights, direct sunlight, etc.). • Damage or obstructions caused by mud, ice, snow, etc. • Interference or obstruction by object(s) mounted onto the vehicle (such as a bike rack). Obstruction caused by applying excessive paint or adhesive products (such as wraps, stickers, rubber coating, etc.) onto the vehicle. • Narrow or winding roads. • A damaged or misaligned bumper. • Interference from other equipment that generates ultrasonic waves. • Extremely hot or cold temperatures. Please do not respond at this stage. In my next message I will give you a few more instructions.

ChatGPT

ChatGPT

Understood, I'll wait for your next instructions before proceeding.

MO

You

Please strictly follow the guidelines when you respond to participants' questions. (1) Your audience is the general public; please use simple words and highlight keywords in your response to participants' inquiries. (2) Please use bullet points to list the steps for activating or deactivating any function. (3) After you respond to the participant's question, please ask the follow-up question, similar to the one which is mentioned below. "Do you understand how to use this function, or would you like me to explain it to you again? From next message participant will ask you a question, please provide the training as per the above guidelines and provided user manual.

ChatGPT

ChatGPT

Got it, I will follow these guidelines closely and ensure the instructions are clear and easy to understand. I'm ready to assist with any questions the participants may have.

MO

You

Thanks, Please list all the functions available in the vehicle

ChatGPT

ChatGPT

Sure, here are the **Advanced Driver-Assistance Systems (ADAS)** functions available in the vehicle:

- **Autopilot on (AP-On):** Automatically controls all maneuvers of the vehicle, integrating several safety features.
- **Autopilot off (AP-Off):** Deactivates the autopilot function, requiring manual driving.
- **Lane Keeping Assist (LKA):** Alerts and assists in keeping the vehicle within its lane.

- **Collision Avoidance (CA):** Warns of potential collisions and can autonomously apply brakes.
- **Adaptive Cruise Control (ACC):** Maintains a set speed and distance from the vehicle ahead.

Do you understand how to use these functions, or would you like me to explain any of them to you again?

MO

You

How to activate autopilot function

ChatGPT

ChatGPT

To activate the **Autopilot (AP) function**, please follow these steps:

- **Locate the Autopilot On button:** It's on the right side of the steering wheel.
- **Identify the button:** Among the three buttons on the right side of the steering wheel, the Autopilot button is the topmost one, marked with 'Autopilot on'.
- **Activate:** Press this topmost button to activate the Autopilot function.
- **Confirmation:** A green light will illuminate on the dashboard indicating that the function is active.

Do you understand how to activate the Autopilot function, or would you like me to explain it to you again?

MO

You

How to turn on LKA

ChatGPT

ChatGPT

To turn on the **Lane Keeping Assist (LKA) function**, follow these steps:

- **Find the LKA button:** It's located on the shifter module.
- **Identify the button:** The shifter module's top houses four black buttons arranged like the points of a rhombus. The LKA button is at the topmost point.
- **Activate LKA:** Press the topmost button, which has a symbol of two dashed lines with a vehicle in the middle, to activate the LKA function.
- **Confirmation:** A green light will illuminate on the dashboard, indicating that LKA is active.

Do you understand how to turn on the Lane Keeping Assist, or would you like me to explain it to you again?

MO

You

Please now guide me about collision avoidance function, how to activate that function

ChatGPT

ChatGPT

To activate the **Collision Avoidance (CA)** function, please follow these steps:

- **Locate the control knob:** On the steering wheel, find the two knobs/indicators. Use the knob on the left side of the steering wheel.
- **Identify the CA button:** Look for the symbol depicting two cars next to each other with a few lines in between, representing the Collision Avoidance function.
- **Activate CA:** Turn or press the knob with the Collision Avoidance symbol to activate the CA system.

Once activated, a green light will illuminate on the dashboard, indicating that the Collision Avoidance system is active.

Do you understand how to activate the Collision Avoidance function, or would you like me to explain it to you again?

MO

You

where is adaptive front lighting system located and how I can turn that ON

ChatGPT

ChatGPT

The user manual provided does not include details on an Adaptive Front Lighting System (AFLS). The information shared focuses on the following Advanced Driver-Assistance Systems (ADAS) functions:

- Autopilot on (AP-On)
- Autopilot off (AP-Off)
- Lane Keeping Assist (LKA)
- Collision Avoidance (CA)
- Adaptive Cruise Control (ACC)

For questions about functions like the Adaptive Front Lighting System or any other features not mentioned in the manual, I recommend referring to the specific vehicle's full owner's manual or contacting the manufacturer directly for the most accurate and detailed instructions.

Is there another ADAS function listed that you would like more information on, or would you like to know more details about any of the features I've mentioned?

MO

You

Can you please guide me on the steps to turn on ACC

ChatGPT

ChatGPT

To turn on the **Adaptive Cruise Control (ACC)** function, follow these steps:

- **Locate the ACC buttons:** These are on the shifter module.
- **Identify the buttons:** Look for the first two of the four red buttons located towards the bottom of the shifter module from the left.
- **Activate ACC:**
 - First, press the leftmost button, which is marked with a speedometer symbol.
 - Then, press the second button, labelled 'SET'.
- **Confirmation:** A green light will illuminate on the dashboard, indicating that ACC is activated.

Do you understand how to turn on the Adaptive Cruise Control, or would you like me to explain it to you again?

MO

You

Just to confirm there are total five function, or I am missing any thing

ChatGPT

ChatGPT

Yes, you are correct. According to the manual provided, there are a total of **five ADAS functions** available in the vehicle:

1. **Autopilot on (AP-On)**
2. **Autopilot off (AP-Off)**
3. **Lane Keeping Assist (LKA)**
4. **Collision Avoidance (CA)**
5. **Adaptive Cruise Control (ACC)**

These are the functions highlighted in the manual for the autonomous vehicle (AV) you're learning about. You haven't missed anything based on the information shared.

Do you have any more questions about these functions, or is there anything else you'd like to learn more about?

MO

You

Where is autopilot off function located

ChatGPT

ChatGPT

To turn off the **Autopilot (AP-Off)** function, please follow these steps:

- **Locate the Autopilot Off button:** It's on the left side of the steering wheel.
- **Identify the button:** Among the three buttons on the left side of the steering wheel, the Autopilot Off button is the topmost one, marked with 'Autopilot off'.
- **Deactivate Autopilot:** Press this topmost button to deactivate the Autopilot function.

Once deactivated, the Autopilot function will be turned off, and you will need to manually control the vehicle.

Do you understand how to deactivate the Autopilot function, or would you like me to explain it to you again?

A-3: ChatGPT Interaction Sample-3

This example showcases a third participant engaging with ChatGPT. The interaction demonstrates ChatGPT's consistent and reliable ability to provide detailed explanations of ADAS and AV features in response to the participant's question, adhering to the guidelines outlined in the provided user manual

MO

You

Hello ChatGPT, in my next message, I will provide you with the contents of a user manual for an autonomous vehicle (AV). This manual provides information on how to operate an AV in a simulated environment. Instead of asking the participants to read the manual by themselves, you will digest the contents, and then use an interactive, conversation-based approach to teach the participants how to drive the AV and operate various ADAS functions." [Approaches] "Your goal is to ensure that participants feel confident and capable of using the ADAS functions and operating the AV safely and efficiently after they have received this training from you." [Goals] "Please ensure that the guide and instructions that you provide to the participants are solely based on the information provided within the given manual and do not draw from general knowledge or external resources." [Conditions]

ChatGPT

ChatGPT

Absolutely, I'm ready to assist with this. Please provide the contents of the user manual for the autonomous vehicle (AV), and I'll get started on creating an interactive, conversation-based training guide based on the information you share.

MO

You

WELCOME to ChatGPT based Autonomous Vehicle interactive training! Owner's Manual Welcome to the ChatGPT based Autonomous Vehicle interactive training platform where you will learn how to operate an Autonomous Vehicle (AV) in a simulated environment, specifically focusing on the utilisation of the Advanced Driver-Assistance Systems (ADAS). This guide will walk you through each step, providing clear instructions on how to use each ADAS feature available in the car. Driving seat environment: When you're in the driver's seat, you'll find the steering wheel in front of you with the shifter module next to it (on the right side), and pedals underneath. On your screen, the front (bonnet) of your AV is displayed in red. Please note when any of the ADAS function is activated, a green illuminated light on the screen will indicate that the function is active. ADAS and AV functions available in the car: There are five functions available in this car, • Autopilot on (AP-On) • Autopilot off (AP-Off), • Lane keeping Assist (LKA) • Collision Avoidance (CA) • Adaptive Cruise Control (ACC) Below is a guide on how to operate each of these functions. 1. Autopilot (AP) Function Description: Auto pilot function consist of below safety features. When this function is ON system automatically controls all the manoeuvres of the vehicle. Please note that it does not replace the driver. It is the driver's responsibility to stay alert, drive safely, and be always in control of the vehicle. When Autopilot function is off in that case you need to manually drive the vehicle. • Adaptive Cruise Control • Lane Keeping Assist • Collision Avoidance • Blind Spot Assist How to Turn on Autopilot • The AutoPilot On button is located on the right side of the steering wheel. • There are three buttons on the right side of the steering wheel. • The AutoPilot button is the topmost button among these. It's marked with the label 'Autopilot on'. Press this button to activate the function. • When this function is activated, a green light will illuminate on the dashboard. How to Turn off AP • The AutoPilot Off (AP-off) button is located on the left side of the steering wheel. • There are three buttons on the left side of the steering wheel. Press this button to deactivate the autopilot function. • The AutoPilot Off button is the topmost button among these. It's marked with the label 'Autopilot off' 2. Lane Keeping Assist (LKA) function Description: The Lane Keeping Assist alerts when the vehicle is about to run off the road or exit the lane. If required system will make necessary manoeuvres to keep the vehicle in the desired lane. This camera-based system warns starting at a minimum speed. The minimum speed is country-specific and is displayed in the menu for the intelligent Safety systems. Warnings are issued by means of a steering wheel vibration. The severity of the steering wheel vibration can be adjusted. The system does not provide a warning if the turn signal is set before leaving the lane. The system thus helps keep the vehicle in the lane. How to turn on LKA • The LKA button is located on the shifter module. • The shifter module's top houses four black buttons arranged like the points of a rhombus, and the LKA button is at the topmost point. • The symbol for LKA is represented as two dashed lines with a vehicle in the middle. Press this button to activate the LKA function. • When this function is activated, a green light will illuminate on the dashboard. 3. Collision Avoidance (CA) Function Description: The system may prevent some accidents. In the event of an accident, the system may reduce impact speed. The system sounds a warning before an imminent collision and activates brakes independently, if needed. Depending on the equipment version, the system is controlled by the following sensors: • Camera in the

area of the interior mirror. • Radar sensor in the front bumper. The system issues a two-phase warning of a possible risk of collision with vehicles at speeds above approx. 10 km/h. The timing of warnings may vary with the current driving situation. With the vehicle approaching another vehicle intentionally, the approach control warning and braking is delayed in order to avoid false system reactions. How to turn on CA • On the steering wheel, there are two knobs/indicators, one on the left side and one on the right side. • The knob on the left side of the steering wheel is used to turn on and off the CA system. • The symbol for the Collision Avoidance button depicts two cars next to each other with a few lines in between.

4. Adaptive Cruise Control (ACC) Function: Description:

Using this system, a desired speed and a distance to a vehicle ahead can be adjusted using the buttons on the steering wheel. The system maintains the desired speed on clear roads. For this purpose, the vehicle accelerates or brakes automatically. If a vehicle is driving ahead of you, the system adjusts the speed of your vehicle so that the set distance to the vehicle ahead is maintained. The speed is adjusted as far as the given situation allows. When the system is on it maintains the distance of 2.4 sec to vehicle Infront of you depending on the speed. A radar sensor is located in the front bumper and a camera on the interior mirror to detect vehicles driving ahead of you. Depending on the vehicle setting, the cruise control settings may change under certain conditions. For instance, acceleration can change depending on the driving mode. The distance can be adjusted in several steps. For safety reasons, it depends on the respective speed. If the vehicle ahead of you brakes to a halt, and then proceeds to drive again within a brief period, the system can detect this within the given system limits. When the Adaptive Cruise Control (ACC) function is activated in your vehicle and it detects a vehicle directly in front of you, the system will respond as follows to maintain safety:

- **Speed Adjustment:** The system will automatically reduce your vehicle's speed to maintain a safe following distance.
- **Distance Maintenance:** It keeps a set distance from the vehicle ahead, calculated at a time gap of 2.4 seconds, which adjusts based on your speed.
- **Automatic Braking:** If the vehicle in front slows down or stops, the ACC will apply the brakes to maintain the distance.
- **Resuming Speed:** If the vehicle in front speeds up or moves out of the lane, the ACC will automatically accelerate back to your set cruising speed. The system uses radar and cameras to monitor the distance to the vehicle ahead and ensure that a safe following distance is maintained at all times.

How to turn on ACC •

The ACC button is located on the shifter module. • The ACC function is controlled by the first two of the four red buttons located towards the bottom of the shifter module from the left. First, press the leftmost button, which is marked with a speedometer symbol. Then, press the second button, labelled 'SET'. • A green light will illuminate on the dashboard when ACC is activated.

Warnings and system limitations

Many factors can impact the performance of Autopilot components, causing them to be unable to function as intended. These include (but are not limited to):

- Poor visibility (due to heavy rain, snow, fog, etc.).
- Bright light (due to oncoming headlights, direct sunlight, etc.).
- Damage or obstructions caused by mud, ice, snow, etc.
- Interference or obstruction by object(s) mounted onto the vehicle (such as a bike rack). Obstruction caused by applying excessive paint or adhesive products (such as wraps, stickers, rubber coating, etc.) onto the vehicle.
- Narrow or winding roads.
- A damaged or misaligned bumper.
- Interference from other equipment that generates ultrasonic waves.
- Extremely hot or cold temperatures.

Please do not respond at this stage. in my next message I will give you few more instructions.

ChatGPT

ChatGPT

Understood! I'm ready to proceed with the next set of instructions or information you have regarding the autonomous vehicle (AV) interactive training. Please go ahead when you're ready.

You

Please strictly follow the guidelines when you respond to participants questions. (1) Your audience is the general public; please use simple words and highlight keywords in your response to participants' inquiries. (2) Please use bullet points to list the steps for activating or deactivating any function. (3) After you respond to the participant's question, please ask the follow-up question, similar to the one which is mentioned below. "Do you understand how to use this function, or would you like me to explain it to you again? From next message participant will ask you question, please provide the training as per the above guidelines and provided user manual.

ChatGPT

ChatGPT

Absolutely, I'll adhere to the guidelines provided and ensure my responses are clear, simple, and concise, with an emphasis on keywords and using bullet points for instructions. I'll also engage with follow-up questions to ensure comprehension and readiness to proceed. I'm ready to assist with any questions the participants might have regarding the operation of the autonomous vehicle (AV) and its Advanced Driver-Assistance Systems (ADAS).

You

I am new driver, please list all the functions available in the AV

ChatGPT

ChatGPT

Certainly! Here's a list of the **functions available** in the Autonomous Vehicle (AV) along with a brief description for each:

- **Autopilot on (AP-On):** Activates the car's autopilot system, which automatically controls driving tasks but requires you to stay alert and in control.
- **Autopilot off (AP-Off):** Deactivates the autopilot system, returning full control of the vehicle to you.
- **Lane Keeping Assist (LKA):** Helps keep the vehicle within its lane by alerting you if the car starts to drift out of its lane and can make minor steering adjustments.
- **Collision Avoidance (CA):** Warns you of potential collisions with objects or vehicles ahead and can autonomously apply brakes to avoid or mitigate a collision.
- **Adaptive Cruise Control (ACC):** Maintains a set speed and distance from the vehicle ahead, automatically adjusting speed to maintain that distance.

Do you understand how to use these functions, or would you like me to explain any of them to you again?

MO

You

Please tell me how I can activate autopilot function

ChatGPT

ChatGPT

Activating the **Autopilot (AP)** function is straightforward. Here are the steps:

- **Locate the Autopilot On button:** It's on the **right side of the steering wheel**.
- **Identify the button:** Among the **three buttons** on the right side, the Autopilot button is the **topmost** one, marked with the label '**Autopilot on**'.
- **Activate Autopilot:** Press **this button** to activate the Autopilot function.
- **Confirmation:** A **green light** will illuminate on the dashboard, indicating that the Autopilot is active.

Remember, even with Autopilot active, it's crucial to stay alert, keep your hands on the steering wheel, and be prepared to take control of the vehicle at any time.

Do you understand how to activate the Autopilot function, or would you like me to explain it to you again?

MO

You

What are the steps to turn on ACC

ChatGPT

ChatGPT

To turn on the **Adaptive Cruise Control (ACC)**, follow these simple steps:

- **Locate the ACC buttons:** They are on the **shifter module**.
- **Activate ACC:** Use the first two of the four **red buttons** towards the bottom of the shifter module.
 - **First button:** Press the **leftmost button**, marked with a **speedometer symbol**.
 - **Second button:** Then, press the **second button**, labelled '**SET**'.
- **Confirmation:** A **green light** will illuminate on the dashboard, indicating that ACC is activated.

This system helps maintain a safe distance from the car ahead by automatically adjusting your speed.

Do you understand how to turn on the Adaptive Cruise Control, or would you like me to explain it to you again?

MO

You

Thanks, please guide me to turn on CA

ChatGPT

ChatGPT

To turn on the **Collision Avoidance (CA)** function, just follow these steps:

- **Find the CA knob:** Look for two knobs/indicators on the **steering wheel**, one on the left and one on the right.
- **Activate CA:** Use the **knob on the left side** of the steering wheel.
- **Identify CA button:** The symbol for the Collision Avoidance button shows **two cars next to each other with a few lines in between**. Press this to turn on the CA system.

Once activated, a green light will illuminate on the dashboard, indicating that the Collision Avoidance system is active and ready to assist in preventing or mitigating collisions.

Do you understand how to turn on the Collision Avoidance function, or would you like me to explain it to you again?

MO

You

Where is LKA function located and how I can turn that on

ChatGPT

ChatGPT

The **Lane Keeping Assist (LKA)** function can be activated with the following steps:

- **Locate the LKA button:** It's on the **shifter module**.
- **Find the button:** The shifter module has four black buttons arranged like the points of a rhombus. The **LKA button is at the topmost point**.
- **Symbol for LKA:** It's represented as **two dashed lines with a vehicle in the middle**. Press this button to activate the LKA function.
- **Activation confirmation:** A **green light** will illuminate on the dashboard, indicating that the LKA is active.

This system helps to ensure your vehicle stays within its lane by alerting you if it starts to drift out of lane and can make minor steering adjustments if necessary.

Do you understand how to turn on the Lane Keeping Assist, or would you like me to explain it to you again?

MO

You

Thaks, please guide me how to turn off autopilot

ChatGPT

ChatGPT

To turn off the **Autopilot (AP)** function, please follow these steps:

- **Locate the Autopilot Off button:** It's on the **left side of the steering wheel**.
- **Find the button:** Among the **three buttons** on the left side, the Autopilot Off button is the **topmost** one, marked with the label '**Autopilot off**'.
- **Deactivate Autopilot:** **Press this button** to deactivate the Autopilot function.

Once you've pressed the button, the Autopilot system will be turned off, and full control of the vehicle will be returned to you.

Do you understand how to turn off the Autopilot function, or would you like me to explain it to you again?

A-4: ChatGPT Responses for Autopilot and LKA Function

This sample compiles ChatGPT's responses to ten different participants regarding Autopilot and LKA functions. It demonstrates the accuracy and conciseness of ChatGPT's answers. By presenting these samples, we aim to show the effectiveness of ChatGPT in assisting users with learning complex AV functionalities. Detailed quantitative metrics and further discussion are provided in Chapter 5, Section 5.4.

Participant 1 - LKA ChatGPT Response length (121 words)

MO

You

How to turn on LKA function

ChatGPT

ChatGPT

To turn on the Lane Keeping Assist (LKA) function in your Autonomous Vehicle, please follow these steps:

- **Find the Shifter Module:** This is located next to the steering wheel.

- **Locate the LKA Button:** Look at the top of the shifter module for four black buttons arranged in a diamond shape. The LKA button is at the top point.
- **Identify LKA Symbol:** The button has a symbol showing two dashed lines with a car in the middle.
- **Activate LKA:** Press the LKA button to activate the function.
- **Confirmation:** A green light on the dashboard will illuminate, indicating that LKA is active.

Do you understand how to turn on the LKA function, or would you like me to explain it to you again?

Participant-1 Autopilot Function (ChatGPT response length 117 words)

MO

You

How to activate Autopilot function?

ChatGPT

ChatGPT

Activating the Autopilot function on your Autonomous Vehicle (AV) is straightforward. Here are the steps:

- **Locate the Autopilot Button:** This is on the right side of the steering wheel.
- **Identify the Button:** Look for the topmost button among the three buttons on the right side of the steering wheel. It's labeled 'Autopilot on'.
- **Activate:** Press the 'Autopilot on' button to activate the function.
- **Confirmation:** A green light will illuminate on the dashboard to indicate that Autopilot is active.

Remember, even with Autopilot active, it's essential to stay alert and maintain control of the vehicle at all times.

Do you understand how to activate the Autopilot function, or would you like me to explain it to you again?

Participant 2 - LKA ChatGPT Response length (125 words)

MO

You

Can you please help me to locate LKA button?

ChatGPT

ChatGPT

Absolutely, let's locate the Lane Keeping Assist (LKA) button together:

- **Find the shifter module:** It's located next to the steering wheel, on the right side.
- **Look for four black buttons:** They are arranged in a rhombus shape on the top of the shifter module.
- **Identify the LKA button:** The topmost point of the rhombus is the LKA button.

- **Recognize the symbol:** The LKA symbol looks like two dashed lines with a vehicle in the middle.

Once you've found the button with this symbol, you can press it to activate the Lane Keeping Assist function. A green light on the dashboard will illuminate to indicate that LKA is active.

Do you understand how to locate and use the LKA button, or would you need further clarification?

Participant-2 Autopilot Function (ChatGPT response length 110 words)

MO

You

How to activate Autopilot function

ChatGPT

ChatGPT

Activating the Autopilot function is straightforward. Here are the steps:

- **Locate the Autopilot button:** It's on the right side of the steering wheel.
- **Identify the button:** The topmost button among the three on the right side is for Autopilot. It's labeled 'Autopilot on'.
- **Activate Autopilot:**
 - Press the 'Autopilot on' button.
 - Look for the green light on the dashboard to confirm that Autopilot is active.

Remember, when Autopilot is on, the system controls the vehicle's maneuvers, but it's crucial that you remain alert and ready to take control at any time.

Do you understand how to activate the Autopilot function, or would you like me to go over the steps again?

Participant 3 - LKA ChatGPT Response length (129 words)

MO

You

How to use LKA

ChatGPT

ChatGPT

Using the **Lane Keeping Assist (LKA)** feature is straightforward. Here are the simple steps to activate it:

- Locate the **LKA button** on the shifter module.
- Look for the topmost button among four black buttons arranged like a rhombus; this is the LKA button.
- The LKA symbol looks like two dashed lines with a vehicle in the middle. **Press this button** to activate the LKA function.
- A **green light** will illuminate on the dashboard, indicating that the LKA function is active.

The LKA system will help keep your vehicle within its lane by alerting you with a steering wheel vibration if it detects that you're about to veer off course.

Do you understand how to use the LKA function, or would you like me to explain it to you again?

[Participant-3 Autopilot Function \(ChatGPT response length 161 words\)](#)

MO

You

How to use Autopilot

ChatGPT

ChatGPT

To use the **Autopilot (AP)** function in your autonomous vehicle, follow these simple steps:

- **To Turn on Autopilot:**
 - Find the **AutoPilot On button** on the right side of the steering wheel.
 - Look for the **topmost button** among the three buttons on the right side. It's marked with 'Autopilot on'.
 - **Press this button** to activate the Autopilot function.
 - A **green light** will illuminate on the dashboard, indicating the function is active.
- **To Turn off Autopilot:**
 - The **AutoPilot Off (AP-off) button** is on the left side of the steering wheel.
 - Among the three buttons on the left side, the **topmost button** is marked with 'Autopilot off'.
 - **Press this button** to deactivate the Autopilot function.

Remember, when Autopilot is on, the system controls the vehicle's maneuvers but does not replace the driver. It's crucial to stay alert, drive safely, and always be in control.

Do you understand how to use the Autopilot function, or would you like me to explain it to you again?

[Participant 4 - LKA ChatGPT Response length \(129 words\)](#)

MO

You

How to operate LKA

ChatGPT

ChatGPT

Operating the **Lane Keeping Assist (LKA)** is straightforward. Here are the steps to activate it:

- **Locate the LKA button** on the shifter module.
- **Find the topmost button** on the shifter module, which has four black buttons arranged like the points of a rhombus.

- **Press the LKA button**, represented by two dashed lines with a vehicle in the middle, to activate the function.
- **Look for a green light** on the dashboard, which indicates the LKA function is active.

Once activated, LKA will help keep your vehicle within its lane by alerting you through a steering wheel vibration or making corrections if it detects the vehicle is drifting out of the lane.

Do you understand how to use this function, or would you like me to explain it to you again?

Participant-4 Autopilot Function (ChatGPT response length 124 words)

MO

You

Please help me to turn on autopilot function

ChatGPT

ChatGPT

To turn on the **Autopilot (AP) function** in your car, follow these simple steps:

- **Locate the Autopilot buttons** on the right side of the steering wheel.
- **Identify the topmost button** among the three buttons on the right side, marked with the label 'Autopilot on'.
- **Press the 'Autopilot on' button** to activate the Autopilot function.
- **Look for a green light** on the dashboard, which indicates that the Autopilot function is now active.

Remember, when Autopilot is activated, the system will automatically control the vehicle's maneuvers. However, it's crucial to stay alert, drive safely, and be ready to take control of the vehicle at any time.

Do you understand how to activate the Autopilot function, or would you like me to explain it to you again?

Participant 5 - LKA ChatGPT Response length (126 words)

MO

You

please tell me easy way to turn on LKA

ChatGPT

ChatGPT

To turn on the **Lane Keeping Assist (LKA)** in an easy way, follow these steps:

- Find the **shifter module** next to the steering wheel.
- Look for **four black buttons** arranged like a rhombus on the shifter module.
- The **LKA button** is at the **topmost point** of this arrangement.
- It's marked with a symbol of **two dashed lines** with a **vehicle** in the middle.

- **Press** this button to activate the LKA function.
- A **green light** will illuminate on the dashboard, indicating the function is **active**.

This feature helps keep your vehicle within its lane by alerting you and adjusting the steering if necessary.

Do you understand how to turn on the Lane Keeping Assist (LKA) function, or would you like me to explain it to you again?

Participant-5 Autopilot Function (ChatGPT response length 96 words)

MO

You

How to activate Autopilot function

ChatGPT

ChatGPT

To activate the **Autopilot** function, follow these simple steps:

- **Locate the buttons** on the **right side of the steering wheel**.
- Find the **topmost button** on this side, which is marked with '**Autopilot on**'.
- **Press** this button to turn the Autopilot function **on**.
- A **green light** on the dashboard will indicate that the Autopilot function is **active**.

This will enable the vehicle to automatically control maneuvers, but remember to stay alert and in control at all times.

Do you understand how to activate the Autopilot function, or would you like me to explain it to you again?

Participant 6 - LKA ChatGPT Response length (136 words)

MO

You

Please tell me where is LKA button and what is process to activate that?

ChatGPT

ChatGPT

To activate the **Lane Keeping Assist (LKA)** feature in your Autonomous Vehicle (AV), you need to locate the LKA button and follow these steps:

- **Find the LKA button:** It's located on the **shifter module** next to the steering wheel.
- **Identify the button:** Look for the **topmost button** on the shifter module, which has a symbol showing **two dashed lines with a vehicle in the middle**.
- **Activate LKA:** **Press this button** to activate the Lane Keeping Assist function.
- **Confirmation:** A **green light** will illuminate on the dashboard to indicate that LKA is active.

This system helps ensure your vehicle stays within its lane by alerting you and making necessary maneuvers if it detects the car is drifting.

Do you understand how to use the LKA function, or would you like me to explain it to you again?

Participant-6 Autopilot Function (ChatGPT response length 124 words)

MO

You

Autopilot button is on shifter module or steering wheel and how we can activate the function?

ChatGPT

ChatGPT

The **Autopilot (AP)** button is located on the **steering wheel**, not on the shifter module. Here's how you can activate the Autopilot function:

- **Locate the AP button:** It's on the **right side** of the steering wheel.
- **Find the right button:** Among the three buttons on the right side, the **Autopilot button** is the **topmost** one, marked with the label '**Autopilot on**'.
- **Activate Autopilot:** **Press this button** to activate the Autopilot function.
- **Confirmation:** A **green light** will illuminate on the dashboard, indicating that Autopilot is active.

Remember, even with Autopilot engaged, it's crucial to stay alert and maintain control of your vehicle at all times.

Do you understand how to activate the Autopilot function, or would you like me to explain it to you again?

Participant 7 - LKA ChatGPT Response length (149 words)

MO

You

Please guide me where is LKA located and it is easy to use?

ChatGPT

ChatGPT

Sure, I'll guide you on how to locate and use the **Lane Keeping Assist (LKA)** function. It's designed to be user-friendly. Here's how to find and activate it:

- **Location:** The LKA button is located on the **shifter module** next to the steering wheel.
- **Identification:** Look for four black buttons arranged like the points of a rhombus on the shifter module. The LKA button is at the **topmost point**.
- **Symbol:** It's represented by two dashed lines with a vehicle in the middle.
- **Activation:**
 - Press the LKA button to activate the function.
 - A **green light** will illuminate on the dashboard, indicating the LKA function is active.

LKA helps keep the vehicle within its lane by alerting you or making necessary maneuvers if the vehicle starts to drift out of its lane.

Do you understand how to use the LKA function, or would you like me to explain it to you again?

Participant-7 Autopilot Function (ChatGPT response length 124 words)

MO

You

What is process to turn on autopilot function

ChatGPT

ChatGPT

Turning on the **Autopilot** function in the simulated Autonomous Vehicle (AV) is straightforward. Here are the steps to activate it:

- **Location:** The Autopilot On button is on the **right side** of the steering wheel.
- **Identification:**
 - There are three buttons on the right side of the steering wheel.
 - The Autopilot button is the **topmost button** among these.
- **Activation:**
 - Press the button marked with the label '**Autopilot on**' to activate the function.
 - A **green light** will illuminate on the dashboard, indicating the Autopilot function is active.

Remember, even with Autopilot activated, it's essential to stay alert and in control of the vehicle at all times.

Do you understand how to turn on the Autopilot function, or would you like me to explain it to you again?

Participant 8 - LKA ChatGPT Response length (138 words)

MO

You

Where is LKA function located and how I can turn that on

ChatGPT

ChatGPT

The **Lane Keeping Assist (LKA)** function can be activated with the following steps:

- **Locate the LKA button:** It's on the **shifter module**.
- **Find the button:** The shifter module has four black buttons arranged like the points of a rhombus. The **LKA button is at the topmost point**.
- **Symbol for LKA:** It's represented as **two dashed lines with a vehicle in the middle**. Press this button to activate the LKA function.

- **Activation confirmation:** A **green light** will illuminate on the dashboard, indicating that the LKA is active.

This system helps to ensure your vehicle stays within its lane by alerting you if it starts to drift out of lane and can make minor steering adjustments if necessary.

Do you understand how to turn on the Lane Keeping Assist, or would you like me to explain it to you again?

Participant-8 Autopilot Function (ChatGPT response length 127 words)

MO

You

Please tell me the steps to activate the autopilot functions

ChatGPT

ChatGPT

To activate the **Autopilot (AP)** functions in your autonomous vehicle, follow these steps:

- Look for the **three buttons** on the **right side of the steering wheel**.
- The **Autopilot On button** is the **topmost** among these buttons.
- It's labeled with '**Autopilot on**'. Press this button to activate the Autopilot function.
- A **green light** will illuminate on the dashboard to indicate that the Autopilot is active.

When Autopilot is activated, it automatically controls the vehicle's maneuvers, incorporating safety features like Adaptive Cruise Control, Lane Keeping Assist, Collision Avoidance, and Blind Spot Assist. Remember, it's crucial to stay alert and maintain control over the vehicle even when Autopilot is engaged.

Do you understand how to activate the Autopilot function, or would you like me to explain it to you again?

Participant 9 - LKA ChatGPT Response length (130 words)

MO

You

Where is LKA function located on steering wheel or shifter module and how to turn on?

ChatGPT

ChatGPT

The Lane Keeping Assist (LKA) function is located on the **shifter module**, not on the steering wheel. Here's how to turn it on:

- **Location:** Find the **shifter module** next to the steering wheel.
- **Identification:** Look for four black buttons arranged like the points of a rhombus on the top of the shifter module. The LKA button is at the **topmost point**.

- **Symbol:** The LKA button is represented by a symbol showing **two dashed lines with a vehicle in the middle**.
- **Activation:**
 - Press the **LKA button** at the topmost point of the shifter module.
 - A **green light** will illuminate on the dashboard, indicating that the LKA function is active.

Do you understand how to locate and activate the LKA function, or would you like me to explain it to you again?

Participant-9 Autopilot Function (ChatGPT response length 117 words)

MO

You

Can you please guide me where is autopilot function located and how the symbol looks like

ChatGPT

ChatGPT

Absolutely, here's how to locate and recognize the Autopilot function:

- **Location:** The Autopilot On button is located on the **right side of the steering wheel**.
- **Symbol:** The button is marked with the label '**Autopilot on**'. It is the **topmost button** among the three buttons on the right side of the steering wheel.

To activate the Autopilot function, follow these steps:

- Find the **right side** of the steering wheel.
- Identify the **topmost button**, labeled '**Autopilot on**'.
- **Press** this button to activate the function.
- A **green light** will illuminate on the dashboard indicating the function is active.

Do you understand how to locate and activate the Autopilot function, or would you like me to explain it to you again?

Participant 10 - LKA ChatGPT Response length (109 words)

MO

You

How to turn on LKA

ChatGPT

ChatGPT

To turn on the **Lane Keeping Assist (LKA)** function, follow these steps:

- **Find the LKA button:** It's located on the shifter module.

- **Identify the button:** The shifter module's top houses four black buttons arranged like the points of a rhombus. The LKA button is at the topmost point.
- **Activate LKA:** Press the topmost button, which has a symbol of two dashed lines with a vehicle in the middle, to activate the LKA function.
- **Confirmation:** A green light will illuminate on the dashboard, indicating that LKA is active.

Do you understand how to turn on the Lane Keeping Assist, or would you like me to explain it to you again?

Participant-10 Autopilot Function (ChatGPT response length 95 words)

MO

You

How to activate autopilot function

ChatGPT

ChatGPT

To activate the **Autopilot (AP) function**, please follow these steps:

- **Locate the Autopilot On button:** It's on the right side of the steering wheel.
- **Identify the button:** Among the three buttons on the right side of the steering wheel, the Autopilot button is the topmost one, marked with 'Autopilot on'.
- **Activate:** Press this topmost button to activate the Autopilot function.
- **Confirmation:** A green light will illuminate on the dashboard indicating that the function is active.

Do you understand how to activate the Autopilot function, or would you like me to explain it to you again?

Appendix – B: List of Publications

Paper Contributed Towards the Thesis.

- M. Murtaza, C.-T. Cheng, M. Fard, and J. Zeleznikow, "The importance of transparency in naming conventions, designs, and operations of safety features: from modern ADAS to fully autonomous driving functions," *AI & SOCIETY*, pp. 1-11, 2022, doi: 10.1007/s00146-022-01442-x. [Q1 Journal].
- M. Murtaza, C.-T. Cheng, M. Fard, and J. Zeleznikow, "Preparing Drivers for the Future: Evaluating the Effects of Training on Drivers' Performance in an Autonomous Vehicle Landscape," *Transportation Research Part F: Traffic Psychology and Behaviour*, 2023, doi: 10.1016/j.trf.2023.09.013. [Q1 Journal]
- M. Murtaza, C.-T. Cheng, M. Fard, and J. Zeleznikow, "Transforming Driver Education: A Comparative Analysis of LLM-Augmented Training and Conventional Instruction for Autonomous Vehicle Technologies," *International Journal of Artificial Intelligence in Education*, pp. 1-38, 2024, doi: 10.1007/s40593-024-00407-z. [Q1 Journal]

Additional Published Papers Related to the Topic

- M. Murtaza, C.-T. Cheng, M. Fard, and J. Zeleznikow, "Supporting Driver Training - from Vehicles with Advanced Driver Assistance Systems to Fully Autonomous Vehicles," in *Autonomous Vehicle Technology conference-APAC21*, Melbourne, Australia, 2022: FISITA and SAE, 2023. [Online]. Available: <https://www.fisita.com/library/apac-21-136>. [Conference Paper]
- M. Murtaza, C.-T. Cheng, M. Fard, and J. Zeleznikow, "Assessing Training Methods for Advanced Driver Assistance Systems and Autonomous Vehicle Functions: Impact on User Mental Models and Performance," *Applied Sciences*, vol. 14, no. 6, p. 2348, 2024, doi: 10.3390/app14062348.

Appendix – C: Human Research Ethics Approval

STEM College

College Human Ethics Advisory
Network (CHEAN)
Email: humanethics@rmit.edu.au
Tel: [61 3] 9925 4620

Notice of Approval

Date: **22 February 2022**

Project number: **25022**

Project title: **Framework for Autonomous Vehicles Regulation in Australia**

Risk classification: **Negligible/Low**

Chief investigator: **Dr Ben Cheng**

Status: **Approved**

Approval period: From: **22/02/2022** To: **21/02/2025**

The following documents have been reviewed and approved:

Title	Version	Date
Risk Assessment and Application Form	5	21/02/2022
Participant Information Sheet and Consent Form	5	21/02/2022
Recruitment Material	5	21/02/2022
Research Instruments	5	21/02/2022

The above application has been approved by the RMIT University CHEAN as it meets the requirements of the *National Statement on Ethical Conduct in Human Research* (NHMRC, 2007).

Terms of approval:

1. Responsibilities of chief investigator

It is the responsibility of the above chief investigator to ensure that all other investigators and staff on a project are aware of the terms of approval and to ensure that the project is conducted as approved by CHEAN. Approval is valid only whilst the chief investigator holds a position at RMIT University.

2. Amendments

Approval must be sought from CHEAN to amend any aspect of a project. To apply for an amendment, use the request for amendment form, which is available on the HREC website and submitted to the CHEAN secretary. Amendments must not be implemented without first gaining approval from CHEAN.

3. Adverse events

You should notify the CHEAN immediately (within 24 hours) of any serious or unanticipated adverse effects of their research on participants, and unforeseen events that might affect the ethical acceptability of the project.

4. Annual reports

Continued approval of this project is dependent on the submission of an annual report. Annual reports must be submitted by the anniversary of approval of the project for each full year of the project. If the project is of less than 12 months duration, then a final report only is required.

5. Final report

A final report must be provided within six months of the end of the project. CHEAN must be notified if the project is discontinued before the expected date of completion.

6. Monitoring

Projects may be subject to an audit or any other form of monitoring by the CHEAN at any time.

7. Retention and storage of data

The investigator is responsible for the storage and retention of original data according to the requirements of the *Australian Code for the Responsible Conduct of Research* (R22) and relevant RMIT policies.

8. Special conditions of approval

Nil.

In any future correspondence please quote the project number and project title above.

Yours faithfully,

Professor Falk Scholer
Chair, STEM College Human Ethics Advisory Network

Cc	Student Investigator/s:	Mr Mohsin Murtaza
	Other Investigator/s:	Prof Mohammad Fard, Prof John Zeleznikow