Transactions on Computer Science and Intelligent Systems Research
ISSN: 2960-1800, eISSN: 2960-2238 | Volume 5
AIDML 2024

Study of Interaction Interface of Vehicles for Automatic Driving

Zhixin Meng *

Wuhan International Yangtze River High School, Wuhan, China

* Corresponding Author Email: zmeng25@students.wyischina.com

Abstract. With the rapid development of the vehicle and information industries, the traditional vehicle has been transformed from a simple travel tool to an intelligent vehicle with comprehensive functions, intelligence, and rich information. As a standard function of intelligent vehicles, automated driving will greatly reduce or even replace humans for vehicle control, and the human-machine interaction system pays more attention to displaying the driving status and prompting the driver in an intuitive way, to make the driver fully trust the vehicle and obtain safe driving experience. In this paper, I study the development and current application of the interaction interface of vehicles. The main study objective is HUD (Head-Up Display). By introducing different technologies of HUDs, the study describes the examples of interaction interface of HUDs, analyzes the pros and cons of the different applications, and thus presents the direct impression and typical futuristic experience of interaction interface of vehicles. The paper also discusses the human's natural behavior while driving and related future technology advancement is developing, and the driving environment which is the most important topic for the whole industry. The paper analyzes the interaction requirements of automated driving vehicles and summarizes the development trend of the human-machine interaction system for automated driving, which results in better understanding of interaction interface of vehicles.

Keywords: Vehicles Interaction Interface; Automatic Driving; CHUD; WHUD; AR HUD.

1. Introduction

Human-machine interaction is essentially the process of realizing mutual understanding, cognition, and interaction between humans and machines, to accomplish a specific function or task [1]. The vehicle is a typical human-machine interaction system, and traditional vehicles rely on the human driver's eyes, ears, brain, and limbs to cooperate and complete driving operations. In the era of automated driving, driving is completely controlled by vehicle autonomy, establishing the user's sense of trust and pleasure, which is essential for automated driving [2], and is also the goal of the automated driving human-machine interaction system.

Along with the rapid development of vehicle industry and information technology, the cars people are driving today are no longer just a simple transportation instrument, but more like a comprehensive terminal as smartphone which totally changed the way of life. The intelligent cars will not only provides traditional functions of what people are used to, but also offers much more autonomous capabilities.

Xing Rui et al. proposed the use of computer vision technology using artificial intelligence for data perception and collection in vehicles and replacing the human brain in recognizing, reacting, and processing complex information. They also emphasize on the networking safety challenges, such as how to understand the links in the network and it is vulnerable to malware attack; how interactive system store, distribute, access personal private information and provide constructive suggestions [3]. Zhang Daquan et al. analyzed the human-machine interaction requirements for L3 automated driving and proposed three dimensions: user trust establishment, driving responsibility allocation, and driving takeover. It is important for interaction interface system to comply with government standards and try to make innovations based on these standards [4]. Sun Xiaofeng et al. studied the information carrier, information content, and other factors affecting the trust of automated driving human-machine interaction and its mechanism of action, and proposed that "the expression of the interface, the presentation form, and layout affect people's trust in automated driving" [5]. It can be seen that the

vehicle human-machine interaction system itself is one of the important and indivisible functions of automated driving.

2. Automotive Interactive Interface

In the early stage of vehicle development, vehicle's operation status was presented by analog instruments such as speedometer and tachometer with pointer. The information driver needed shown on the cockpit was limited, only critical information was provided. The pointers are not as accurate as drivers wanted, when vehicle was operating the pointer's position was not that easy to be distinguished, especially in not so good darker environment. In order to improve the driver's driving experience and lower the risk of distracted looking and blind driving caused by looking down at the dashboard, HUD (Head-Up Display), was born eventually by the progress of the technology advancement. It was first introduced in military fighter jets to allow pilots to see the information they needed on the windshield without having to look down. It was then implemented in civil vehicles since1988. According to IHS market forecast, since 2022 global HUD penetration will increase rapidly, until 2027 one sixth cars will equip a HUD and the output of the HUD will reach 17 million sets yearly [6-8].

In 2021, China has announced GB/T 40429-2021<<Vehicle Automation Classification>>, according to the standard, it has divided automation into 6 levels, from L0 to L5 class. L0's definition is completely traditional way of driving without any interference of automation system; L1 and L2 bring the requirements of autonomous driving to a level currently most of the cars have achieved, by providing partially assistance to drivers but majority of the responsibility is under the control of drivers. L3 is what the whole autonomous industry is heading to and some of the important applications have been implemented, the key difference is autonomous system has complete authority when the vehicle is facing critical situations. By reaching L4, L5 is not far away, but L4 is another huge challenge for industry to overcome.

Facing great challenges ahead, China's local governments have published various incentive plans to help industry companies move faster towards better autonomous driving. The capital invested in the autonomous system is growing for the recent years. One of the important investment direction is interactive interface. The most immersive and visually informative is Head-Up Display or HUD. HUD has always been a very productive approach to present important information directly at the front of the driver while driver keeps all attention on the road ahead.

There are three kinds of HUDs had been developed throughout the years, and some the them have become the critical interaction interface for future intelligent vehicles.

2.1. CHUD (Combination Head-Up Display)

The CHUD is a projection imaging carrier which is a 6 to 8 inches wide transparent glass in front of the driver, and the projection imaging distance is less than 2 meters. Image information, including speed, navigation, fuel consumption, temperature, etc., is mostly digital information. The display form is relatively simple, and the projection distance is quite short. When switching in the line of sight from near to far, or verse vise, can easily leads to the human lens of eyes focusing fatigue, affecting the driving stability. Although the structure is not complex and the cost is low enough, the use of CHUD was basically obsolete. And, a CHUD was shown in Figure 1

Figure 1. Display of combination ead-up [9]

2.2. WHUD (Windshield Head-Up Display)

The WHUD is a projection imaging carrier installed to the front windshield. The size of it is between 7-12 inches wide, and projection distance is between 2 to 6 meters. The functions of WHUD offer a variety of applications such as entertainment, communication, road conditions, weather, traffic alarms, and other information. Since WHUD was invented, it gradually became the current mainstream of the HUD form. Up to now, WHUD has installed similar operating system like smartphone to offer driver apps the same as on the smartphone and those apps providers also help WHUD manufacturers to develop customized HUD version to best support display of the applications on windshield. The WHUD now also has added voice control functions which completely liberates driver's hands to remaining on steering wheel as much as possible. However, there are still challenges facing this WHUD technology, such as, the projection quality is affected by glass thickness which causes glass reflection; some owners of the vehicle like to add a film on windshield that it can blur the image projected on the glass; looking too frequently from far to near on the image projected will make driver more easily to get tired. The lightness of image is another challenge. Although it is applicable under current technology which can provide visible image during day time, the quality of the image is not satisfied enough. A typical WHUD was shown in Figure 2.

Figure 2. A typical WHUD [10]

2.3. AR HUD (Augmented Reality Head-Up Display)

By combining virtual reality technology, AR-HUD displays the relevant information on the windshield at a natural distance, and the overall imaging size is larger and of higher quality. Thanks to the development of AR solution and related optical technology advancement, AR HUD can offer bigger display up to 50 inches and better field of view. Because the display is much wider and bigger, engineers can combine virtual information to real physical traffics. For example, AR HUD can directly generate direction arrows on real world road to show which way you should follow real time. It also can interact with other vehicles in front of the driving vehicle showing critical information such as distance between the driving vehicle and the vehicle ahead, precautious warning on other vehicles might run in the way driving vehicle which might cause potential safety risk. Huawei's AR HUD was shown in Figure 3.

Figure 3. Huawei's AR HUD [11]

AR-HUD not only can fully integrate the intelligent cockpit and ADAS-related safety driving functions together, but also bring an immersive experience for drivers. Huawei has announced an innovative AR HUD in later 2023 on its new car M9, the solution can provide 75 inches big display which combines reverse car image, parking image and higher resolution of 2k. When the car parks, guests can also enjoy immersive movie in the car [7].

3. Automated Driving Interaction Content and Programs

The content of human-machine interaction for automated driving, especially the richness of safety-related information, will affect people's trust in automated driving. The interaction should be able to accurately obtain the vehicle's driving status and intuitively transmit information, and then combine with the vehicle's own intelligent driving decisions to realize the pleasure and trust of automated driving.

1) Road conditions and early warning: Based on displaying navigation information such as distance, time, route, speed limit, etc., it judges and predicts potentially dangerous situations through a variety of sensors, and reminds drivers to pay attention or take over in time. Especially monitoring and reminding in complex environments, such as traffic jams, multi-intersection roads, night driving, and other environments, monitoring people and cars near the vehicle's road, reminding and warning the driver, and even slowing down and emergency braking when necessary.

2) Vehicle condition monitoring: Through the HUD realize the display of the current vehicle conditions and driving information. Such as tire pressure monitoring, fuel/power, range, and other vehicle conditions; speed, RPM/power, energy consumption, and other driving status.

3) Understanding of driver's intentions: Through the Driver Monitor System for fatigue detection, emotion recognition, gesture recognition, vision tracking, etc., and then use AI for emotional analysis,

and combined with other parts of the car to make appropriate reminders and improvements. For example, if it detects that the driver has become drowsy, it uses music and vibration to help keep him awake.

4) Manipulation and confirmation: Through the voice to issue driving route navigation, speed adjustment, air conditioning adjustment, window adjustment, dialing the phone, playing music, and other operating instructions; the vehicle through the voice or HUD synchronized feedback results, can greatly reduce the cognitive load of controlling the vehicle, but also allows the driver to focus on the road, to ensure a safer atmosphere.

4. Trends in Automated Driving Interactions

At present, voice interaction, gesture control, biometrics, AR, and other technologies are being widely used in the intelligent cockpit system of vehicles, and the interaction mode of vehicle driving has moved from the interaction mode of physical buttons and physical displays to the interaction mode of non-contact and automated perception, which continues to enhance the intelligent and safe driving experience.

With the development of artificial intelligence technology, the human-machine interaction system will show a comprehensive and personalized development trend [8], the vehicle can intelligently learn and adapt to personal habits and preferences, to achieve the same car can provide different interaction interfaces for different people.

In the long run, once the brain-computer interface technology becomes mature, the driver do not need to interact with the vehicle through the limbs, voice, face expression, or display, the vehicle can drive directly according to the human character and intention, and the person can also feel the driving state directly.

The development of automotive human-machine interaction technology will enter the stage of intelligentization together with the vehicle.

5. Conclusion

Although vehicle interaction interface has always been a critical system for intelligent autonomous driving, the interaction system still has a long way to go. HUDs are quite direct and intuitive one of the most useful solutions to interaction interface system. CHUD will become obsolete, and WHUD will still play an important role for some time, the future of HUD solution will be AR HUD and vehicle intelligentization. As the autonomous driving emerging in the future, vehicle will need much more powerful display solution to support human machine interaction, and also to integrate various autonomous functions on the vehicle, such as ADAS, intelligent cockpit, and entertainment system. To support the development of better HUD system, various technologies must have breakthrough, from biometrics to aritificial intelligence, and even brain interface. In the future study and development of more advanced interaction interface, industry needs to take advantage of cloud computing, and builds dedicated massive data centers to support huge computing power as more and more data will be collected via modern vehicles, especially data from interaction interface. The interaction interface system has to be standardized one day when various applications have been integrated into the system. Different manufacturers will develop its own specified interface and make it hard to comply with regulations related to safety, network protocols and other environments. The interaction interface itself is not only an individual system, but also an essential interface connects human and vehicle. The more intelligent the vehicle is, the better the interaction interface has to be developed and integrated into the intelligence platform.

References

[1] Dong Wei, Li Yan, Dong Qi, Qu Jin-dai, Liu Ao, Dong Liang. Overview of Research on Autopilot Human-computer Interaction System, China Academic Journal Electronic Publishing House, No. 10 (2022) 1.

[2] Continental Group, A combined human interactive solution for autonomous driving, World Cars Magazine, 2020

[3] Xing Rui, Su Zhou, Key safety technology for autonomous driving networking of human interactive interface, AI-VEW, 1st issue (2021).

[4] Zhang D., Zhang H., Yang D., et al. Research on HMI for Level 3 Autopilot [J].Automotive Digest (Chinese), 2020(1): 32-35.

[5] Sun Xiao Feng, Zhao Ying, Lyu Chun Mei, Influencing Mechanism of Human-Computer Interaction Trust in Autonomous Vehicles, Journal of Northeastern University(Natural Science), Vol.43, No.9 (September, 2022)

[6] Vehicle Blog. About Car's trending application of HUD: AR-HUD - OFWeek. https://display.ofweek.com/2022-07/ART-230001-8330-30568167.html. (2022).

[7] SoHu Sports. Wenjie M9 released, Huawei ARHUD redefines intelligent driving to a new level. Sports. https://sports.sohu.com/a/747276310_121098202. (2023).

[8] Lin Shu Ping, Human interactive safety issue of autonomous driving era, Journal of Safety and Environment, 2023, 23(3).

[9] Ad by daily beast shop, why this heads-up display is the navigation option for you, Daily Beast, https://www.thedailybeast.com/why-this-heads-up-display-is-the-navigation-option-for-you (2017).

[10] Journal car talk, Better sight than CHUD, wider, farther, do you see this kind of WHUD from Cheluobu Intelligence, Autohome, https://chejiahao.autohome.com.cn/info/9277302, (2021).

[11] Huawei News, Huawei's AR HUD debuts in Munich international auto expo, starting a new era of driving experience, Huawei's official website, https://www.huawei.com/cn/news/2021/9/huawei-ar-hud-iaa-mobility-2021 (2021).