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The development status and trends of automotive interactive systems

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Abstract. Nowadays, as time passes and science and technology improve, the interactive system of autos becomes more common, and there are far-reaching changes from the original. As autonomous driving and other functions become more developed, people are increasingly focusing on the car's interactive system. This study investigates automobile development status and trends via the lens of automobile interaction systems, comparing them between previous and present periods, using BYD's electric vehicle interaction system as an example, and briefly exploring the current automobile interaction system. The development characteristics and influencing elements of some automobile interface systems are summarized, and the future development trend is anticipated using this information. Finally, it is determined that the automobile interaction system is progressing toward giving people a more comfortable and safe driving experience, which is a positive trend, and that more technologies may be merged into it in the future. The research in this paper that the vehicle interaction system is currently in development, and while it is merely a simple physical interaction, with the continual integration of new technologies, it has the potential to make significant progress.

Keywords: interactive system, development status and trends, BYD's example

1. Introduction

With the advancement of science and technology, transportation tools are continually being replaced, and electric vehicles (EVs) as green travel tools progressively infiltrate people's daily lives. Automobiles have evolved from traditional modes of transportation to information, digital, and intelligent mobile terminals as advanced technologies such as new energy, the Internet, big data, and artificial intelligence have been developed and applied, and the related interaction design has gradually become the research focus of major automobile companies and academia. This is obvious from Figure 1, which depicts the exponential growth of research articles on autonomous vehicles published during 2000–2020. The automatic driving of various representative EV brands is studied in this context, and the development trend of EVs is described on this basis. It is clear from this image in Figure 1 that cars are transitioning from gasoline vehicles to electric vehicles, and that people's demand for electric vehicles is increasing. Not only is it more environmentally friendly, but it is also safer, and the unmanned driving system carried by EVs is becoming more and more advanced, which can produce more and more powerful protective measures to better protect the safety of drivers and passengers. And, as the Internet, Internet of Things, and other technologies advance, automobiles are becoming more convenient to operate in

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terms of engagement, allowing users to have a better experience. So, this is a positive development [1]. At present, the car interactive system is becoming more and more rich, such as driver attention detection [2], emotion recognition, drowsiness detection [3], mental workload [4], and so on. This paper begins with research based on vehicle interaction systems, first studying the basic classification and its characteristics, then studying the interaction system's development status, then analyzing the development trend and potential future development direction, and finally summarizing the foregoing.

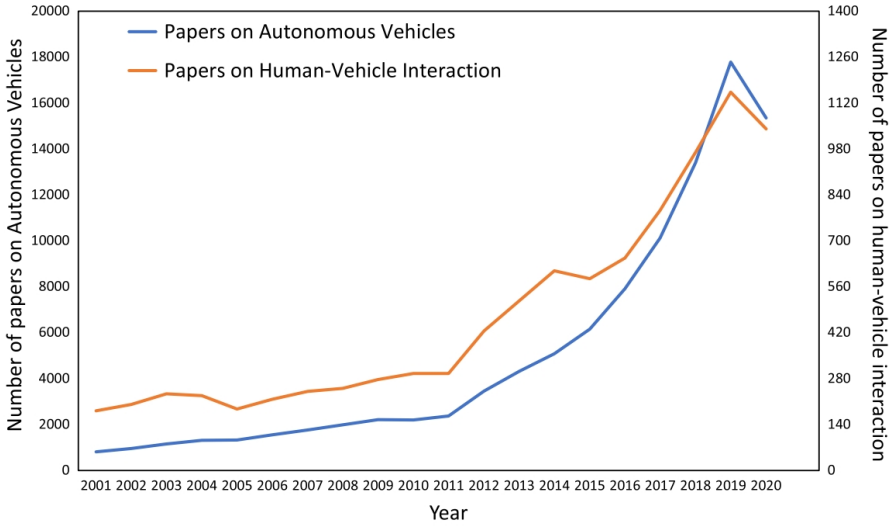

Figure 1. Comparison between number of papers on AVs and human–vehicle interaction over the last 20 years [5]

The significance of this study on vehicle interaction systems stems from the fact that as science and technology advance, new technologies are continually being investigated. Vehicle technology systems are constantly being integrated with new technologies as science and technology advance, and they are also in a vital stage of development. In this work, the taxonomy and development status of vehicle interface systems are briefly discussed. These studies also estimate the development direction and trend of future vehicle technology systems, offering additional guidance for the development of future vehicle interaction systems.

2. Vehicle interactive system

The development status and trend of automobiles should be analyzed primarily through various forms of interaction. This section lists the classification of various forms of interaction, as well as analyzes and infers the development trend of automobiles through various forms of interaction.

2.1. Physical Interaction

The use of the steering wheel, operating lever, brake pedal, and other physical forms of automotive operation are referred to as physical interaction, and they are the primary methods of hardware interaction. Physical interaction is the primary means for humans to control the car at first, and it is also one of the most fundamental forms of human-car interaction. People can communicate and interact with cars by using physical knobs, keys, sliders, and levers. Because of its simple design, ease of operation and learning, and more intuitive operating feedback, physical interaction has been employed till now.

2.2. Interface Interaction

With the exponential increase of information in the car, there are more and more car-related interfaces, so people operate using a range of screens, and feedback has become a mainstream mode of interaction, interface interaction is one of the ways of car software interaction. The automotive interface merges

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complex operations and instructions inside the car into one or more display screens, optimizing interior space and providing a good operating experience for users. At the moment, the interactive interface of the car is not limited to the main driving dashboard, the rear entertainment interface, the rear center control interface, the head-up display, the mobile phone APP interface, the window display, and so on, and the extension of the interaction of the car interface is gradually expanding.

2.3. Natural Interaction

Natural interaction is an emerging automotive software interaction that refers to human-computer interaction based on human natural behavior via computer, artificial intelligence, and other technologies, such as the use of voice, gesture, human body sensing, face recognition, and other interaction methods. Natural interaction, when compared to physical interaction and interface interaction, saves the user's visual resources and reduces the risk of accidents caused by excessive use of visual resources while driving. Natural interaction research and expansion based on human natural behavior, on the other hand, can effectively save operating costs, increase operation fluency, and thus improve user experience [6].

3. Progression of interactive systems

In this section, the interaction systems in different periods of the past and present are analyzed through the development history of automobile interaction, and the development characteristics of automobile interaction systems are expounded to some extent. Self-driving cars rely on sophisticated sensor technologies to understand their surroundings and passengers. Autonomous cars must understand human behavior and intents and offer a feedback interface. In general, the modes of input and output are determined by the human’s sensory capacity. Humans can engage with self-driving automobiles in an unambiguous manner by completing certain activities that recognize human intentions.

3.1. The development of interaction systems

People have interacted with cars primarily through the steering wheel and the start and brake pedals since the advent of car interaction. In the past, most of the interactive systems of the car were mainly buttons, and the interactive forms of radio, air conditioning, etc. were all buttons or knobs, and these interactive forms of visualization were poor, and they were also very cumbersome, which could not bring people intuitive feelings very well, and could not interact efficiently, which would affect the driver to some extent, and the driver's attention was disorganized.

With the advancement of information technology, the upgrading of the automobile interaction system is being accelerated, and the mode of interaction inside the car is changing. In the entire dashboard, the center console is the direct interaction center between people and cars, and the current interaction system has abandoned traditional buttons, mostly based on the display screen, so that the interactive picture can be presented more intuitively in front of the driver. As a result, people's driving experiences become more comfortable and convenient. There are even voice control and unmanned driving systems; these new forms of interaction not only enrich and perfect the car interaction system, but also make driving more convenient.

3.2. A case study: BYD

BYD, China's leading EVs manufacturer, developed the Di Link4.0 intelligent network connection system on its own, which is now standard in all of BYD’s newly launched models. The intelligent rotating central control screen in the car integrates intelligent voice interaction, leisure and entertainment, navigation, and other functions, and users can independently configure the interface layout based on their driving habits and entertainment preferences, fully meeting their personalized needs. In terms of interface display, BYD is project part of the necessary driving information, such as speed, navigation information, speed limit ICONS, and so on, onto the front windshield of the car, requiring the driver to lower his head 3°~7° to obtain the above information, significantly improving driving safety. Furthermore, users can achieve remote interconnection between the mobile APP and the vehicle via Bluetooth and network signals, as well as grasp the car's electricity, driving range, engine status, and

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other functions via the APP, and can remotely open the air conditioning, car high-temperature sterilization, remote car search, and other functions. Some models have incorporated a mobile Near Field Communication (NFC) car key function, in which the mobile phone can unlock or lock the vehicle near the left front exterior rearview mirror command area, thereby resolving the issue of users being unable to use the vehicle due to a misplaced car key.

BYD released an intelligent body control system based on the Internet of Vehicles and Internet of Things technology - "Yunchariot" - in April 2023, which uses human body sensing technology and can control doors, Windows, lights, and other functions with a wave of the palm. At the same time, it can control acceleration, braking, turning, and other automatic driving operations with gestures. This allows the driver to more easily control the vehicle, improving driving safety and stability.

3.3. Future trend of interactive systems

According to current development trends, EVs may be developed more intelligently in the future, and even the driver will be unnecessary; people will only need to start the car, and physical interaction on the car will essentially disappear, replaced by interface interaction and natural interaction. With the advancement of science and technology, the interactive system will be updated in the future, and in the near future, people will just require voice interaction to manage the car. Furthermore, the vehicle engagement system should be updated with new technologies to improve its efficiency and diversity. Figure 2 shows some of the components of a vehicle interface system.

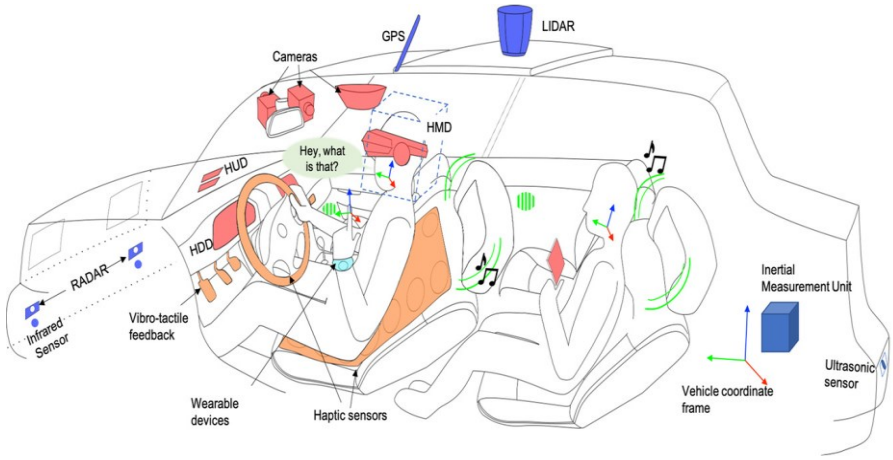

Figure 2. Schematic of in-vehicle interaction [7]

As depicted in Figure 2, visual interfaces and sensors are shown in red, haptic interfaces are shown in orange, exterior sensors are shown in blue, and audio interfaces are shown in green. Head pose recognition is shown in dashed blue lines. In addition, there is a variety of interaction modes, such as eye gaze, hand gestures, and speech displayed [7].

Future automotive interaction technologies may not be limited to in-car entertainment and ride pleasure. The vehicle interaction system will pay more attention to the driver's driving status in non-automatic driving mode to assure driver safety.

Physiological sensing technologies are a very important technology [8]. The electroencephalogram (EEG) is a monitoring method that measures electrical activity in the scalp and is reflective of macroscopic activity on the brain's surface. According to studies on driving distraction, EEG signals are one of the most reliable indicators of driver exhaustion or sleepiness [9,10]. An electrocardiogram (ECG) measures cardiac activity and rate. ECGs are easy to record and can provide a range of signs indicating the driver’s level of attentiveness [11]. Body temperature sensing can show the driver's and passengers’ comfort levels and help manage the temperature in the car based on their particular preferences. According to reports, a range of wearable technologies are utilized to assess body temperature [12].

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The information presented above demonstrates that automobiles are now being examined for future multimodal sensing technology. Its use to identify driver status and monitor driver or passenger behavior is critical for interactive systems. Vehicle interaction systems must estimate and infer driver/user behavior, including weariness or sleepiness, driver cognitive states, and user emotions. The obtained data will be examined to ensure the safety of both drivers and passengers.

4. Influencing factors of vehicles interaction system

The following are the primary factors influencing the evolution of the interactive system of vehicles.

The first one is the influence of vehicle structure change on vehicle interaction systems. Electric vehicles are zero-emission vehicles that are completely powered by rechargeable batteries and use motors as the drive system. They have a simple structure, high energy efficiency, low noise, and zero emissions. Because of the simplification of the body structure, changes in the power and energy supply systems of EVs have resulted in more space in the front row, higher utilization, a more flexible interior layout, and a thinner and lighter instrument panel system [13].

Secondly, intelligent network technology is being developed. The future world is intelligent, and the development of mobile phones, which are the fastest intelligent mobile devices in industrial products, has reached a mature stage, while automobiles are gradually evolving from ordinary travel tools to intelligent mobile terminal products. The interaction between people and cars will become more diverse as a result of intelligent technology, and new interaction methods include interface interaction and natural interaction, which greatly reduces the space occupied by physical interaction buttons.

Thirdly, it is necessary to consider the impact of advances in driverless technology on vehicle interaction systems. Autonomous vehicles are those that can sense their surroundings and navigate themselves without the need for human intervention. Autonomous driving technology can realize information perception of road conditions, predict emergencies, and finally, the intelligent control module can directly decide the driving path of the car. When the driving operation and the supervision of the surrounding environment are taken over by the autonomous driving system, the driver will no longer need to pay attention to the driving task at all times, but will instead participate more in the group interaction in the car [14]. Autonomous driving frees up people's hands by eliminating the necessity to handle the steering wheel at all times while driving. This brings up new possibilities for interactive systems. It gives the driver more energy to interact with the car in other ways besides driving it. This will help to diversify automotive interaction systems and integrate new technologies.

5. Conclusion

In general the car is changing not only to moving towards a better and more comfortable ride and driving experience, but also to a more comfortable experience and stronger interaction development, as well as the continuous development of assisted driving and autonomous driving. This study provides a quick overview of the classification and development of vehicle interface systems. The vehicle interaction system evolved steadily from the most basic physical interaction, with the introduction of display screens, etc., to interface interaction, such as the display screen on the center console. This advancement has improved people’s driving experiences to some degree. As a result of the ongoing advancement of technology, an increasing number of cars now use natural interface systems, such as the BYD example mentioned above. This natural contact significantly enhances people's driving safety and comfort.

This report describes the classification and development status of a vehicle interface system. The investigation revealed that the vehicle interface system is currently in development and is combined with emerging technologies to improve it further. Following the study, the future development path of the vehicle interface system is explained, laying a solid foundation for future vehicle interaction system improvement and providing some proposals. However, more research is needed to better integrate the new technology into the vehicle interface system.

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