Article

Comparative Study of Human-Computer Interaction Interfaces Between Intelligent Cars and Traditional Cars

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Abstract: ***Background:*** The advancement of smart vehicle technologies has made human-computer interaction (HCI) interfaces more critical in enhancing user experience and safety. Compared with traditional cars, smart cars provide more sophisticated and intelligent HCI interfaces by integrating advanced technologies. ***Purpose:*** This study aims to analyze the differences in HCI interfaces between smart cars and traditional cars, as well as their impact on driving experience and safety. Additionally, it is intended to promote the design and innovation of HCI in smart cars. It helps manufacturers to integrate cutting-edge technologies and enhance competitiveness. It also serves as a reference for automobile manufacturers and designers to balance technological advancement and user needs, and to promote the development of the automobile industry towards intelligentization. ***Methods:*** Through literature review, the study analyzes the development, design concepts, and technical applications of human-computer interaction interfaces between intelligent and traditional automobiles providing theoretical support for future research. The case study examines typical intelligent cars and traditional automobile central control interfaces, comparing the two in terms of information presentation, interaction mode, and personalized settings. Comparative research selects sample cases of traditional cars and smart cars, analyzes the differences in interaction interfaces, and identifies the needs and challenges of users. ***Conclusion:*** In comparison of human-computer interaction interfaces between smart cars and traditional cars, smart cars significantly provide a more convenient user experience, which is difficult to achieve in traditional cars. Traditional cars, on the other hand, focus more on the usability and interaction efficiency. Therefore, when designing the interaction system for smart cars, it is necessary to take into account humanization and user habits, simplify functionality, and ensure that drivers can smoothly transition into the smart driving environment so as to enhance the fun of interaction.

Keywords: Smart Car; Conventional Car; Human-computer Interaction Interface; Comparison

1. Introduction

1.1 Background of the Study

With the change of times and the progress of science and technology, traditional automobiles are gradually transforming into intelligentization and informationization. The human-computer interaction (HCI) between traditional and intelligent automobiles mainly reflects the differences in intelligence and personalization. Traditional cars rely on mechanical buttons and dashboards, with relatively single functions and a fixed user experience. Smart cars, on the other hand, introduce touchscreens, voice recognition and artificial intelligence to provide diverse functions such as real-time information, navigation, entertainment and vehicle monitoring. This development has been made possible by the Internet of Things and big data technologies, which enable vehicles to be closely integrated with users' lifestyles, providing personalized services and enhanced safety, significantly improving the user experience.

As consumer demand for convenience and intelligence rises, smart cars are becoming the future direction of development. As a result, many countries have introduced a large number of policies on smart vehicles in the areas of top-level strategies, standards, regulations, and management systems. For example, China issued the "14th Five-Year Plan for the Development of the Digital Economy" and the "Circular on Supporting the Construction of a New Generation of Artificial Intelligence Demonstration and Application Scenarios" in 2024, which clarified the market outlook and created favorable production and business conditions for the development of the smart driving industry. On March 1, 2024, the California Public Utilities Commission approved a plan to expand driverless cab services in Los Angeles and the San Francisco Peninsula. At this stage, the U.S. government regulates the development of the industry through relevant regulations and guidelines, while continuously exploring new modes of business in key basic fields and forward-looking technologies. Furthermore, the plan facilitates the continuous development of automated driving technology and continuous innovation with the help of market applications. Nowadays, consumers' demand for automobiles has gone beyond the basic transportation function, and they are eager for a more convenient and humanized interaction experience, pursuing efficient, convenient, personalized, and intelligent solutions.

1.2 Purpose of the Study

This study aims to deeply analyze the differences in HCI interfaces between intelligent vehicles and traditional vehicles, as well as the impacts of these differences on driving experience and safety. To clarify successful cases and their deficiencies, and also to identify the limitations of the current technology and the future development trends. To provide manufacturers with the basis for integrating cutting-edge technologies, to enhance the competitiveness of their products, and to promote the continuous innovation and optimization of the human-computer interface of intelligent vehicles. This study provides valuable references for automobile manufacturers and designers to help them better balance technological advances and user needs in future automobile design and promote the whole automobile industry to develop steadily in the direction of intelligence.

1.3 Research Methods

The study uses literature research to gather information and analyze and summarize the data. The search includes academic literature, technical data, research reports, industry standards, and other types of information related to human-computer interaction interfaces in smart cars and traditional cars. Then, deeply analyze the literature to grasp the development trajectory, design ideas and technical applications of human-computer interaction interfaces in intelligent and traditional automobiles. Sort out the characteristics, advantages, and disadvantages of both, so as to provide theoretical support and reference basis for the subsequent research.

Through the case study method, the center control interface of a typical smart car and a traditional car is selected as the research object. Identify their advantages and disadvantages by comparing the specific functions and user experience of the two. Analyze their performance in terms of information display, interaction mode, and personalized settings. By comparing specific cars, the advantages of intelligent cars in terms of operation convenience and personalized services are visually demonstrated. Additionally, the stability and intuitiveness of the human-computer interaction interface of traditional cars are revealed as to how it can satisfy the preferences of certain users.

Perform a comparative study to deeply analyze the human-computer interaction interface of intelligent cars and traditional cars. Typical cases of representative traditional car models are selected. Specifically, analyze the differences in the hardware facilities and interaction methods of the interface, and pinpoint the user needs and pain points by comparing the performance of the two in terms of information display complexity and operation convenience. This not only provides strong support for exploring the form of human-computer interaction in the automobile field but also lays a foundation for predicting the development trend of human-computer interaction interface design.

1.4 Content of the Study

Firstly, consult an extensive selection of domestic and foreign literature and cite relevant research results to conduct a directed analysis of the characteristics of both. Secondly, conduct an in-depth analysis and comparison by reviewing typical cases. On this basis, sort out the differences, advantages, and disadvantages of the two. Finally, the human-computer interaction interfaces of traditional cars and intelligent cars are summarized, with an outlook on future development direction and design proposals to promote the optimization and innovation of automotive human-computer interaction interfaces.

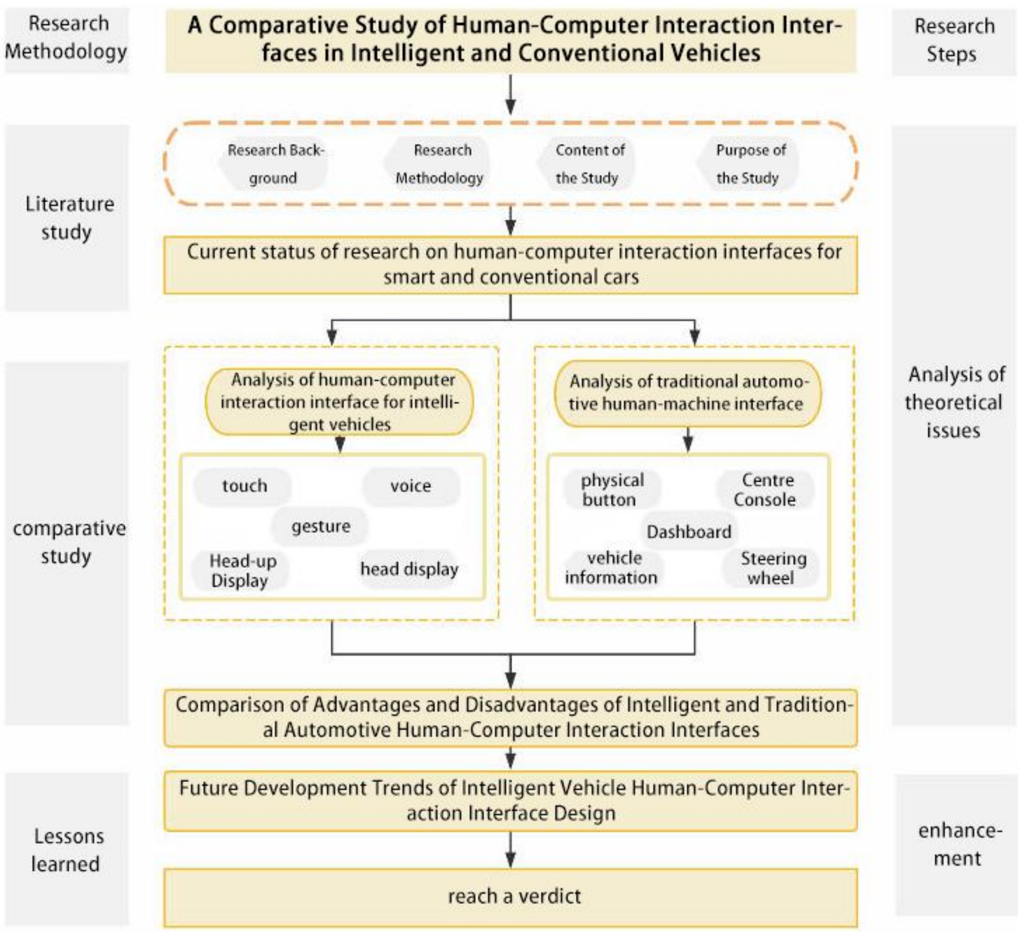

Figure 1: Thesis framework

2. Overview of Papers

The article "Automobile Instrument Panels for the Real World" addresses user experience research by adapting to the specific needs of automotive design teams, discussing recommendations for automotive instrument panel design as well as elaborating on design methods. The article titled, "A Personalized Car" investigates the application of personalization within a driving environment, including a survey of attitudes towards personal settings, and examines the possible advantages and disadvantages of such features (Ericsson, et al. 2006). In Research on Multi-Channel

Interactive Interfaces in Automobiles Based on Wuhan Users, behavioral focus is taken as the core. Using a combination of interviews and scenario descriptions, along with existing multi-channel interaction technologies, to conduct an in-depth study on current automotive human-computer interaction (Liao, 2010). Research and Practice on Interaction Design of Future Compact Family Vehicles examines and summarizes the user knowledge involved in a particular user group of near-future compact family vehicles (Huang, 2016). The study of Design and Application of Automobile Intelligent Instrument Panel Interface adopts a user-centered design concept to explore intelligent and humanized instrument panel design to replace the display of the car's central control screen, enhance technological advancement and speed, and improve users' safety and cognition (Zhang, 2022). The article "Opportunities and Challenges of Utilizing Personality Traits for Personalization in HCI" discusses the main opportunities and challenges of assessing and utilizing personality traits in personalized interactive systems and services (Sarah Theres Völkel et al., 2019). User-centered design (VI): Human Factors Approaches for Intelligent Human-Computer Interaction explores the relationship between user intent recognition and human-computer collaboration based on the concept of user-centered design and identifies key human factors issues that need to be focused on in future research. It also identifies key human factors issues that need to be addressed in future research (Wei Xu， 2021). After analyzing these articles, it is concluded that user experience is increasingly significant to research, which focuses on drivers' psychological and behavioral responses when employing HCI interfaces, as well as exploring how interfaces can be designed to enhance user satisfaction and acceptance.

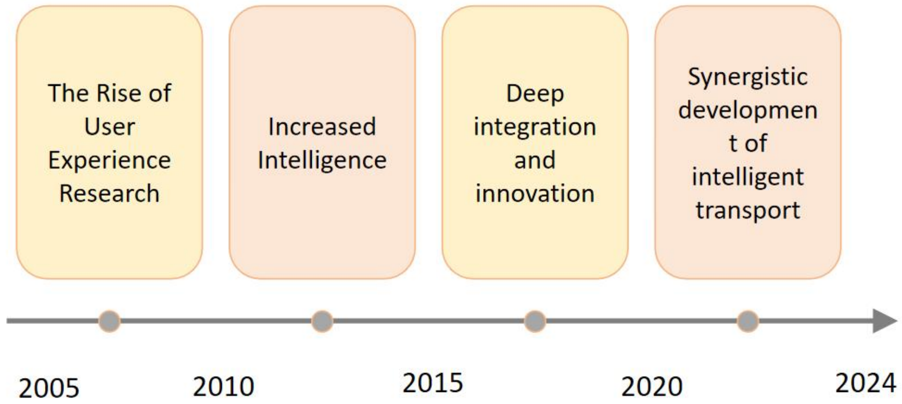

Figure 2: Characteristics of the study

Regarding the enhancement of the degree of intelligence in the "Research on Mobile Application Program Design of Automotive Human-Computer Interaction Based on Android Platform," the article launched in-depth research on the design of human-vehicle interaction based on the user research data, combined with the existing technological research results in the field. It comprehensively considered the elements of safety, experience, interaction, and convenience, focusing on human-vehicle interaction design (Yan, 2014). Research on pieTouch is a direct touch gesture interface for interacting with in-vehicle information systems. pieTouch argues that using a dual-task evaluation methodology allows for a comparison between its design and a generalized touch system, which confirms that one's own design exhibits higher usability and efficiency (Ronald Ecker, 2009). The impact of interface design and safety is discussed in the study "Evaluation of Different Speech and Touch Interfaces to In-Vehicle Music Retrieval Systems" where it is concluded that multi-round speech interfaces significantly increase the time and effort required by drivers to complete tasks (L Garay-Vega, 2010). "Eyes on the Road, Hands on the Wheel: Thumb-based Interaction Techniques for Input on Steering Wheels" examines how gestural text input methods can enable participants to maintain speed and avoid accidents while selecting and operating a vehicle (Iván E. González, 2007). “Application and Development Trends of Artificial Intelligence Technology in Automotive Production” argues that artificial intelligence technology, with its ability to perceive, learn, and make decisions intelligently, can give machines and systems a higher level of intelligence, leading to more accurate, efficient and flexible production (Lui et al, 2024). “Research on Human-Computer Interaction System of Intelligent Connected Vehicle Based on Computer AI Artificial Intelligence Technology” presents an AI-based real-time in-vehicle human-computer interaction information dissemination system based on driving behavior recognition. This system is easy to operate, provides a good human-computer interaction experience, reduces the driver's psychological burden, improves safety, and maintains low response latency (Wei Bing,2023). “Intelligent Cockpits for Connected Vehicles: Taxonomy, Architecture, Interaction Technologies, and Future Directions” provides an overview of the definition, intelligence level, functional areas, and technological framework of intelligent vehicle cockpits. This paper reviews the definition, intelligence level, functional areas, and technical framework of intelligent vehicle cockpits based on the core mechanism of human-computer interaction and summarizes the current research status of related key technologies. Finally, the challenges facing the field of the intelligent cockpit are analyzed, and future development trends are anticipated (Fei Gao,2024). After analyzing these articles, it is concluded that the increasing intelligence of the human-machine interaction interface in intelligent vehicles allows for the application of AI algorithms to predict driver behavior and provide intelligent assistance.

Regarding deep integration and innovation, in the Research on Usability Evaluation of 3D Interaction Gestures in Vehicles, this study explored the basic theory of 3D gesture usability and its application in the automotive field, adopting a fuzzy comprehensive evaluation method to quantitively assess the usability of 3D gestures in vehicles (Zhang, 2018). The Application of Intelligent Speech Recognition Technology in Vehicle-Machine Interaction Systems explains that this technology is used to understand the user's needs more efficiently, thereby providing personalized services that match their expectations (Du, 2024). The article “Hidden Voice Commands: Attacks and Defenses on the VCS of Autonomous Driving Cars,” argued that advances in deep learning have contributed to the rapid development of voice control systems, which are vulnerable to attacks involving hidden voice commands that are not detectable or understandable to humans, and discusses feasible defense strategies (Man Zhou, et al., 2019). The Application of Biometrics in Automobiles mentions that automobiles are constantly evolving in the direction of intelligence and electrification. The application of biometric technology not only provides convenience for users but also subconsciously changes people's perception of automobiles (Gu, 2019). The study of Automotive Human-Computer Interaction Design Based on the Theory of Intuitive Interaction combines the current research results in the field of human cognition, elaborates on the definition and characteristics of intuitive interaction, and discusses the value of intuitive interaction in automotive interaction design by combining relevant design cases (Zhong, 2024). Analysis of the Development Status and Application Trend of In-vehicle Biometrics Technology is an in-depth study of biometrics and sensing technology, which enables automobiles to acquire biologically similar sensing capabilities, hence enabling a more humanized interaction between the vehicle and its occupants (Left, 2019). In the study "Design Study on the Effect of Intelligent Vehicles Interaction Mode on Drivers' Cognitive Load", the multi-resource theory is used to analyze the interaction mode of smart cars, evaluate the impact of physical interaction and other factors on the driver's cognitive load, and derive principles for human-computer interaction design in the intelligent automotive system (Liu & Qi, 2023). All of these articles focus on investigating and developing integrated human-computer interaction interfaces, enabling drivers to control and manage various vehicle functions more conveniently.

The 'Project Design of the Intelligent Connected Vehicle and Intelligent Transportation Application Demonstration Zone' conducts research on the construction of intelligent connected vehicles and intelligent transportation applications from the aspects of roadside intelligent facilities and equipment, testing and application systems, and management frameworks, forming a demonstration zone with functions such as open road testing, autonomous driving applications, 5G-based intelligent connected applications, and intelligent transportation applications (Guo, 2020). Review of Vehicle Surveillance Using IoT in the Smart Transportation Concept.' This research aims to identify solutions for problems in transportation, especially intelligent transportation, to connect all the systems that have been established using intelligent transportation. This research presents a system proposal applicable for further research and development of smart cities, especially in the field of smart transportation (Nur Kumala Dewi, 2021). The research 'Internet of Things-Based Smart Transportation System for Smart Cities' discusses vehicle-to-vehicle communication and vehicle-to-infrastructure communication and discusses an Internet of Things-based smart parking system for smart cities, as well as an Internet of Things-based smart transportation system for smart cities (Fantin Irudaya Raj, 2022). The research on the design of in-vehicle navigation interfaces from the perspective of intelligent transportation theory, explores its advantages and development trends in China, while also conducting practical exploration of a combined in-vehicle navigation interface based on intelligent transportation principles (Sheng, 2023). Heilongjiang Province should actively promote the integration and innovation of a new generation of intelligent technologies with the transportation industry to expedite the construction of smart cities with intelligent transportation, and inject new momentum into the high-quality development and sustainable revitalization of Longjiang (Hong, 2024). Recent articles indicate that the coordinated development of intelligent vehicle human-machine interaction interfaces and intelligent transportation systems has become the focus of research, emphasizing the utilization of these interfaces to achieve information interaction between vehicles and transportation infrastructure to improve traffic efficiency and safety.

Table 1: Summary of Literature Features

Research Direction	Reference	Trait
User Experience Research	A Study of Multi-Channel Interactive Interfaces for Automobiles Based on Wuhan Users. Design space for driver-based automotive user interfaces.	User experience is increasingly becoming a key research area, with studies focusing on the psychological and behavioral responses of drivers when employing human-computer interfaces, as well as exploring how interfaces can be designed to enhance user satisfaction and acceptance.
Increased Intelligence	A Study of Mobile Application Design for Automotive Human-Computer Interaction Based on the Android Platform. Patent Analysis of Multi-Sensor Fusion Technologies for Intelligent Vehicles. DAARIA: Driver assistance by augmented reality for intelligent automobile.	Explore the picture art of children's film creation and analyze the audio-visual language and narrative structure.
Deep integration and innovation	A Study of Usability Evaluation of Gestures for Three-Dimensional Interaction in Vehicles. An Introduction to the Design and Application of Embedded	The research focuses on the development of an integrated human-machine interface that allows drivers to more easily control and

	Remote Intelligent Vehicle Monitoring System. Experimental autonomous road vehicle with logical artificial intelligence.	manage the various functions of the vehicle.
Intelligent Transportation Collaborative Development	Research on the Design of In-Car Navigation Interfaces from the Perspective of Intelligent Transportation Research on the Integration of Intelligent Urban Transportation and Information Communication Networks An IoT-enabled intelligent automobile system for smart cities	The research focuses on how to use human-machine interaction interfaces to achieve information interaction between vehicles and transportation infrastructure, and improve transportation efficiency and safety.

To summarize, there are relatively few comparative studies on human-computer interaction between conventional and smart cars, and the existing studies mainly focus on developing smart cars. This bias may lead to a lack of understanding of the potential of traditional cars in terms of user experience and interaction design. With the rise of smart cars, the complexity and intelligence level of interface design are increasing, and drivers need to adapt to new interaction methods such as touch screens, voice control, and gesture recognition. Studies comparing the two can reveal the effects of different interaction modes on driver attention, fatigue, and overall safety. Therefore, exploring the differences in design principles, user experience and safety between traditional and smart cars is crucial for future interaction design. In addition, as smart cars are becoming more popular, it is especially critical to understand the psychological adaptation process of traditional car users as they transition to smart cars. This helps manufacturers to better consider users' needs and habits when designing new models, leading to more humanized designs. Although the research on human-computer interaction in smart cars has gained extensive attention, the interaction mode of traditional cars also deserves in-depth exploration. Future research should focus on the comparison between the two to promote the overall development of HCI design and ensure that the user experience continues to improve while technology advances.

3. Characterization of Human-Computer Interaction Interface for Intelligent Vehicles

3.1 Touch Interactive Interface

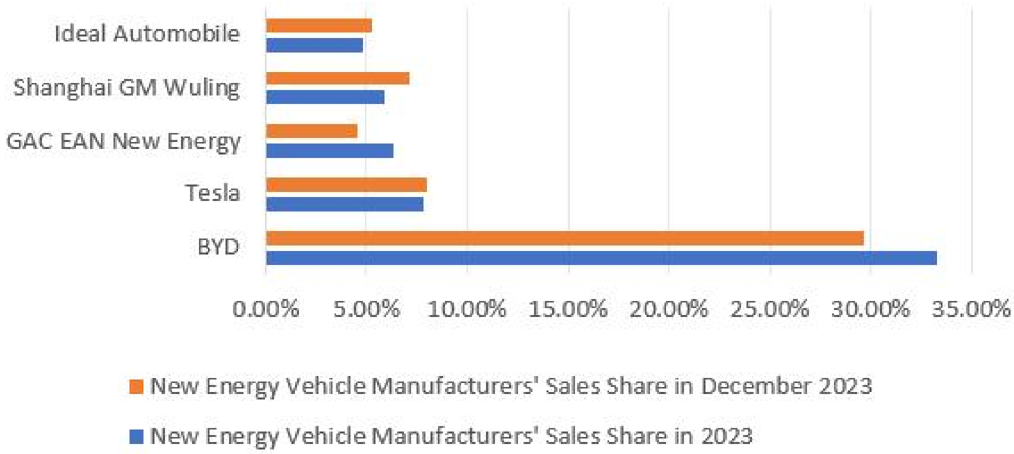

Figure 3: Change in sales of new energy vehicle manufacturers

Source: China Mobile Internet Database

In the comparison of human-computer interaction interface between intelligent cars and traditional cars, the importance of the touch interface as a key part of intelligent cars cannot be disregarded. As shown in Figure 3 the change in sales of new energy vehicle manufacturers are becoming more popular, and new technologies are gradually gaining consumer recognition. The touch interface provides drivers with a convenient operating experience by being intuitive and responsive. Tesla's touch interface allows users to change the theme color and style of the car's screen according to their personal preferences (Figure 4), and drivers can choose among various styles and contents according to their habits and needs. However, the touch interface operates differently than traditional physical buttons, which can lead to driver distraction and misuse. Maintaining concentration is crucial in driving, and frequent touch operations may increase the risk associated with driving. Therefore, it is important to balance convenience and safety when designing touch interfaces to ensure driving safety and ease of operation.

Figure 4: Tesla touch interface

Source: https://www.tesla.com/

3.2 Voice Interaction Interface

Today's voice technology has become the key to intelligent vehicle-machine interaction systems, helping users to accurately operate a variety of complex functions, as well as providing personalized services by inferring user intent through the analysis of voice information. Voice recognition technology enables drivers to control multiple functions of the vehicle through voice commands, thus effectively reducing operational distractions, enhancing driving safety, reducing long-time gazing at the screen and deviation from the road ahead, and minimizing perceptual load. However, the voice interaction interface also has certain limitations. For example, the voice recognition system may have recognition errors or disruptive interference. In addition, potential security risks must be considered, as attackers may use hidden voice commands to control self-driving cars. Such a situation reminds us of the need to enhance security and reliability in the development and use of voice technology to ensure a safe driving process.

3.3 Gesture Interaction Interface

As a free interaction method, gesture interaction breaks through the limitations of interface size and creates a broader place for users to interact. Compared with touch screens, gesture interaction reduces visual attention distraction and overcomes the intangibility of voice interaction, thus enhancing the driving experience. Compared to the physical buttons of traditional automobiles, gesture interfaces are easier to locate and use, and can be operated effectively with less attention. However, the disadvantage of gesture interaction is the lack of haptic feedback, which may reduce user satisfaction and safety as the user is unable to confirm that commands are correctly recognized. Therefore, designing gesture interaction systems that effectively supplement haptic feedback or enhance the sense of user confirmation is a key direction for enhancing user experience.

3.4 Header Display Interactive Interface

The Head-Up Display interactive interface projects information such as navigation, speed, and safety warnings onto the windshield, creating virtual graphics that overlap with the real driving environment. Head-up display systems allow drivers to maintain a better sense of their environment by eliminating the need to look down or avert their eyes than traditional methods of presenting information that relies on dashboard and center console screens. However, with the increased functionality of smart vehicles, too much information can lead to information overload, making it difficult for drivers to access key information quickly, increasing confusion and distraction. Therefore, when designing head-up display interfaces, it is necessary to balance information richness and simplicity to ensure that drivers can effectively access the information they need to ensure safe driving.

3.5 Biometric Interaction Interface

Unlike traditional cars, which rely mainly on mechanical buttons or relatively simple electronic controls, the biometric technology used in smart cars can effectively identify the driver's identity, greatly streamline operating procedures, and enhance the user experience by meeting individual needs. In the field of biometric interaction, smart cars not only identify emotions and determine whether the driver is distracted, but also monitor personal interests, psychological state, and health status, thereby maximizing driving safety. Although biometric technology is highly convenient and unique in terms of identity verification, it still has the potential to be spoofed compared to the physical controls of traditional cars. Some biometric features, such as fingerprints, faces, or voices, can sometimes be copied or forged. Especially in the absence of effective protective measures, such attacks may pose a threat to system security. Therefore, when using biometric technology, enhanced security measures are required to ensure that user information and driving safety are not compromised.

Table 2: Intelligent vehicle human-computer interface characteristics

Intelligent vehicle human-machine interface	Specificities	Photograph
Touch Interactive Interface	Intuitive and fast response	
Voice Interaction Interface	Personalized service, no manual operation	
Gesture Interactive Interface	Breaking through interface size limitations with fewer visual distractions	
Head-up Display Interactive Interface	Reducing Driving Distractions	

Biometric interaction interface	Simple operation and customizable to individual needs	

4. Analysis of the Characteristics of Traditional Automotive Human-Computer Interaction Interface

4.1 Physical Button Interface

In contrast to the flexible touch interfaces of smart cars, the human-machine interaction in conventional vehicles is mainly based on physical controls. It plays a key role in ensuring safe, efficient, and convenient operation while driving. For example, drivers use control buttons and dials to operate functions such as wipers, lights, and the horn and can use physical buttons on either side of the steering wheel to execute commands quickly. Compared to the recently developed intelligent vehicle human-machine interaction technology, the tactile feedback generated by most physical buttons makes them easier to find and use, and they can be operated with less attention. Although intelligent vehicle touchscreen technology gives the interface the ultimate flexibility, its physical characteristics make it relatively static, limiting the number and type of user interfaces it supports. Therefore, when designing a human-machine interaction system, it is necessary to consider how to effectively combine the advantages of physical operation with the flexibility of an intelligent interface so as to improve the user experience and safety.

4.2 Center Console Interactive Interface

The center console, located in the center of the cockpit and dashboard, serves as the control panel for the entire vehicle, bringing together the controls for numerous in-car devices. Like BMW cars, the center console interface includes audio-visual entertainment devices, air conditioning controls, and navigation systems, to name a few. (Figure 5). The center console of a traditional car relies on physical buttons and knobs, which are straightforward to operate and provide tactile feedback for safe and efficient operation while driving. In contrast, the center consoles of smart cars rely on large-size touchscreens, which can display information clearly and extensively, integrate multiple functions, display real-time vehicle status and driving data, and provide personalized settings, which significantly improve the driving experience and safety performance. Therefore, when designing the human-computer interaction system, it is necessary to effectively combine the advantages of physical operation with the flexibility of intelligent interfaces to optimize user experience and safety.

Figure 5: BMW center console

Source: https://www.bmw-emall.cn/usedcar/list

4.3 Dashboard Interactive Interface

The instrument panel is a key part of the automotive interior, serving as a guide for the driver's operation, is an important medium for information communication, and an interface for human-vehicle interaction. The dashboard of traditional cars mainly uses physical dials and buttons to enable various functions. In contrast to the interaction mode of intelligent cars, the pointers and scales on the mechanical or semi-mechanical instrument panel of traditional cars are static, with fixed styles and colors, usually displaying only the basic vehicle operating parameters. While modern drivers have an increasing need for information, traditional instrument clusters are often unable to provide this information comprehensively, resulting in the need to maintain continuous visual attention while driving. Therefore, it is important to improve the functionality and visualization capabilities of instrument clusters to meet the needs of modern drivers.

4.4 Interactive Interface of In-Vehicle Information System

In-vehicle information systems provide a wide range of applications to inform and entertain drivers while driving, with common examples including in-vehicle navigation, communication, and entertainment systems. The information display in traditional vehicles is relatively simple, mainly displaying basic vehicle operating parameters, and is presented in a traditional way with pointer gauges and small monochrome displays. In contrast, the display content of intelligent vehicles is extensive and comprehensive, adopting advanced presentation methods to display real-time navigation information, intelligent driver assistance system and vehicle health monitoring data. The operation of traditional cars is extremely basic, mostly controlled by physical buttons and knobs, while smart cars provide diversified operation methods, making the driving experience more flexible and convenient. This transition not only improves the efficiency of information access, but also enhances the overall driving experience.

4.5 Steering Wheel Interaction Interface

Many automobile steering wheels are equipped with buttons to control entertainment systems, cruise, and environmental settings. As an integral part of the driver's direct contact, the steering wheel not only serves interior and safety functions but also has a great deal of scope for development. It is the most frequently used device by drivers, with essential design characteristics including functional performance, comprehensibility, usability, and physical feel, which directly affect the driver's mood, operating experience, and safety. In contrast, the touch interface of smart cars focuses more on versatility and information display that can be optimized according to user preferences and meets personalized and emotional needs. Combining the design of the steering wheel with the flexibility of the touch interface can provide drivers with a more immersive interactive experience while enhancing overall safety and convenience.

Table 3: Traditional automotive HMI characteristics

Conventional Car	**Specificities**	**Photograph**
Physical button interface	Safe, efficient, convenient, easy to locate and operate	

Center Console Interactive Interface	Safe, efficient, convenient, easy to locate and operate	
Dashboard Interactive Interface	Presentation of basic vehicle operating parameters	
Interactive interface of in-vehicle information system	Drivers provide information and entertainment	
Steering Wheel Interactive Interface	Functionality, understandability, usability and physical feel	

5. Comparison of Advantages and Disadvantages of Human-Computer Interaction Interface between Intelligent Vehicles and Traditional Vehicles

5.1 Intelligent Vehicle Human-Computer Interaction Interface Advantages and Disadvantages

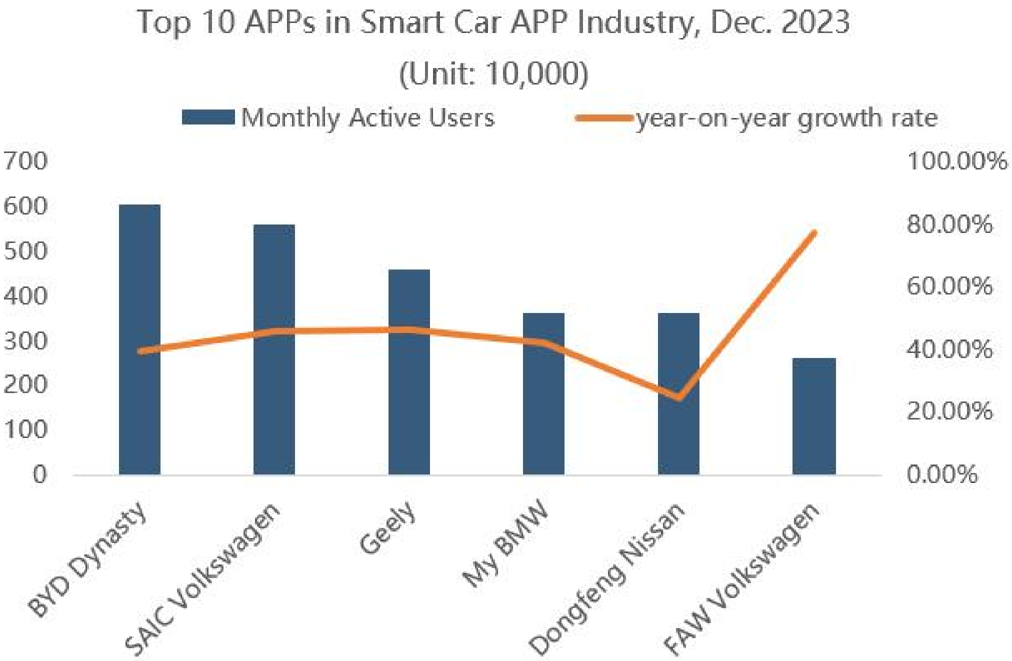

Figure 6: Top 10 APPs in the Smart Car APP Industry, December 2023

Source: https://hea.china.com/article/20240130/012024_1477624.html

People from all walks of life around the world recognize the importance of digital and intelligent interaction. After a long development process, the human-computer interaction concept and technology of smart cars have gradually matured. Figure 6 shows the TOP 10 APPs in the smart car APP industry in December 2023 illustrating an increase in the year-on-year growth rate, indicating that users' demand for smart car services continues to grow. Compared with traditional interfaces that can only display simple information, the large screen of smart cars can present extensive multimedia content and display real-time vehicle status and driver assistance information. The intelligent interaction system actively provides the most suitable information according to the needs of different drivers and scenarios, enhancing the user's psychological experience. However, several studies have pointed out that intelligent human-computer interaction may cause drivers to engage in risky behaviors by increasing the load on the visual and motor systems. This increases the frequency of taking one's eyes off the road while driving and weakening the ability to anticipate potential dangers. Comparison of new energy vehicle sales between January-August 2023 and 2024 indicates a growing preference for intelligent vehicles among users, nonetheless, the safety of intelligent vehicles must be taken seriously (Figure 7). In contrast, the human-computer interaction interface of traditional cars allows drivers to operate blindly through muscle memory due to the familiar design of buttons and knobs. This design reduces line-of-sight interference and improves safety. In addition, with the improvement of automobile data processing capabilities has led to thegradual emergence of data security issues. Data leakage or misuse may seriously threaten user privacy and security. Therefore, it is necessary to strengthen the protection of data security in order to promote the development of smart vehicles.

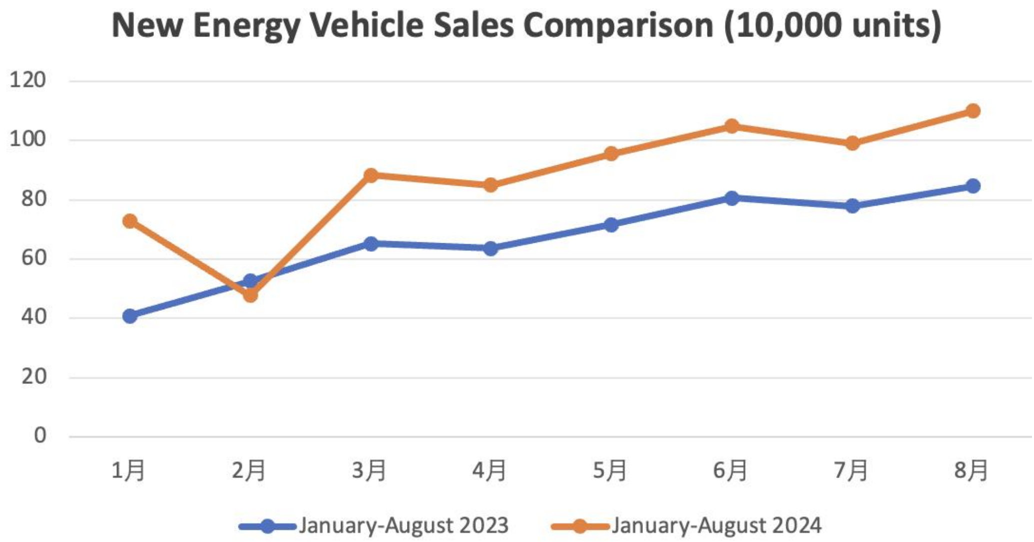

Figure 7: Comparison of New Energy Vehicle Sales in January-August 2023 and 2024

Source: http://www.ccidconsulting.com/#pageSlide1

5.2 Advantages and Disadvantages of Traditional Automotive Human-Computer Interaction Interfaces

The physical operation of a traditional automobile is known for its directness and reliability, utilizing physical buttons and knobs that provide uncomplicated operation and clear feedback. Driver safety is enhanced in this design, which enables drivers to get started quickly and supports blind operation after they become familiar with it. However, the driving experience is limited by the inability of traditional interactive interfaces to provide comprehensive vehicle status information, hence limiting the overall driving experience. In contrast, smart car interfaces are complex and varied, but they can customize the layout, themes, and shortcuts according to user preferences, providing a more natural and convenient operating experience. Although smart systems may have technical failures that affect user experience and driving safety, they are significantly better than traditional cars in terms of information presentation and operational flexibility. Early automotive dashboards were characterized by insufficient data display and poor interaction experience and were unable to meet the complex needs of drivers. As a result, traditional cars are significantly inferior to smart cars in terms of operational flexibility and information presentation.

6. Future Development Trends of Human-Computer Interaction Interface Design for Intelligent Vehicles

6.1 Application of Artificial Intelligence Technology in Human-Computer Interaction

Artificial intelligence technology not only improves driving safety and convenience but also brings a more comfortable and intelligent driving experience. Sensors, cameras, radars, and other equipment are integrated into intelligent driving cars to enable them to perceive the real-time surrounding environment and make appropriate decisions. This technology is widely used in intelligent navigation systems and voice assistants, significantly improving the traveling experience. Compared with traditional automotive human-computer interaction interfaces, the AI functions of smart cars are more diverse, and capable of performing tasks such as face recognition, image retrieval, and object recognition. For example, the system can determine the driver's mood through face recognition and provide warnings and suggestions when the mood is abnormal. For instance, it may play the driver's favorite music to relieve anxiety. In addition, AI can enhance voice recognition capabilities to achieve natural and smooth voice interaction effects, while showing an important role in public opinion monitoring and intelligent customer service.

6.2 Linkage between Human-Computer Interaction Interface and Urban Intelligent Transportation System

Intelligent vehicles represent the trend of future automotive development, and through interconnection with other information systems, they will have a profound impact on automobiles and transportation systems. The intelligent assisted driving capability of the human-computer interaction interface is constantly improving through vehicle networking and intelligence. Meanwhile, the continuous development of intelligent transportation systems plays an optimizing role in urban transportation networks, improves the safety and intelligence level in the scenario of human-machine co-driving, and thus enhances the overall transportation operation efficiency, ensures safety, and improves the public travel experience. Future micro-scenarios may feature real-time route guidance and online command and scheduling by traffic police. Intelligent vehicles can collect real-time driving information, such as positioning, speed, and routes, and these data are uploaded to traffic management platforms through human-computer interfaces, enabling them to effectively supervise, dispatch, and control vehicles. This advancement not only improves driving safety and convenience but also provides more intelligent solutions for urban traffic management.

7. Conclusion

In a comparative study of human-computer interaction interfaces between smart cars and traditional cars, the touch interface of smart cars significantly improves the user experience. Through the high-resolution touch screen, smart cars realize fast response and multi-touch control, while traditional cars rely on physical buttons and focus mainly on usability and system efficiency. Most drivers are familiar with traditional operations, so the design of smart car interaction systems needs to take into account humanization and user habits and reduce learning costs. While retaining the traditional operating experience, smart cars should simplify the use of functions to make them intuitive and natural, ensuring a seamless transition to a smart driving environment and more interesting human-machine communication.

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