Article

# Research on Styling Innovations for Future Driverless Vehicles

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**Abstract:** ***Background:*** Driverless vehicle styling is becoming an emerging research direction in the field of automotive design, driven by advances in autonomous driving technology. Although most of the existing research focuses on the technical aspect, the increasing consumer demand for personalized design has prompted researchers to explore innovative paths for automotive styling design. ***Purpose:*** This study intends to systematically investigate the design trends of driverless vehicles and propose innovative design strategies, thereby providing theoretical support and practical guidance in this field. ***Methods:*** This study adopts literature review method, design theory analysis method, and case study method. This study extensively collects and analyzes relevant literature on styling design of unmanned vehicles, thoroughly explores the impact of unmanned technology on styling design, analyzes advanced design cases both locally and internationally, and conduct empirical research on user needs. ***Results:*** Future designs for driverless vehicle are anticipated to be simplified and fully operational, emphasizing the integration of design idea with national culture in brand identity, while giving importance to environmental protection and sustainable development. The designers of topological theory and artificial intelligence provide a new problem-solving framework. ***Conclusion:*** The innovation of this study lies in the comprehensive use of multiple research methods to deeply analyze the multidimensional influencing factors of driverless vehicle, and to propose innovative design strategies combining new technologies and materials. The results of this study not only provide new perspectives for the styling design of unmanned vehicles, but also contribute forward-looking and practical insights to the innovative development of the automotive industry. Thereby promoting the evolution of automotive design towards smarter, greener, and more humanized vehicles.

**Keywords:** Driverless Vehicles; Styling Design; Topological Theory; Design Trends

## 1. Introduction

### 1.1 Research Background

The design of driverless cars is at the forefront of technological innovation. In particular, L4 and L5 levels of self-driving technology have moved from theoretical research to practical application, heralding a major change in transportation modes. According to projections, the global self-driving car market is expected to reach hundreds of billions of dollars by 2024, demonstrating significant momentum in technological development. This growth is attributed to the interdisciplinary convergence of sensor technology, artificial intelligence, and communication technology. China's projected growth in the Light Detection and Ranging (LiDAR) and automotive chip markets highlights the market's high expectations for these key technologies. LiDAR, a key component in the vehicle's perception of the environment, and automotive chips, the "brain" of the autonomous driving system, are critical to improving the performance of driverless cars. The good performance quality will directly promote the development of driverless car technology. Consumers' expectations of driverless car styling are not only limited to fashionable and beautiful appearance but also focus on the harmony between the vehicle and the environment as well as the satisfaction of personalized needs. With environmental protection and sustainability at the forefront of society, designers must incorporate these concepts into their designs. Designers need to deeply understand market trends and consumer behavior, and use advanced tools such as digital and simulation technologies to improve design efficiency and innovation. They must also communicate with consumers and collect feedback to continuously optimize design solutions. The emergence of new energy technologies has increased dramatically the design freedom of driverless cars, providing designers with a wide range of creative options.

However, although personalized automotive design has gained attention and related studies have emerged, Human Machine Interface (HMI) design for automotive personalization is still in the stage of continuous exploration and in-depth study, with research still lacking systematic organization. This study will summarize and synthesize research on personalized automotive HMI design in the context of personalized automotive demand, combine technology and theory, gain insight into the development trend, and provide new perspectives and ideas for future research on personalized automotive HMI design.

### 1.2 Research Purpose

The purpose of the study is to deeply analyze the fundamental differences between driverless cars and traditional cars in terms of technology. To conduct a detailed comparative study and evaluation of existing driverless models in light of the characteristics of driverless car styling design. In addition, the study aims to explore and predict the potential development trends of future driverless vehicle styling design, and to contribute theoretical references and insights of both prospective and practical value to the field of automotive stylistic design. Furthermore, the authors aim to stimulate designers' creativity to promote a smarter, greener, and more humanized future in the field of the automotive industry, as well as contribute to the sustainable development of society.

### 1.3 Research Methods

Literature search method: through the use of academic resource websites such as Zhi.com and Google Scholar, as well as in-depth study of the research reports of relevant enterprises and scholars, the current research status of unmanned vehicle styling innovation design is comprehensively inquired and understood. In order to explore and have a deeper understanding of the current situation and future development trends of driverless car styling innovation design.

Data collection method: Pinterest, Behance, and other well-known industrial design websites are utilized to systematically research many design cases of driverless car modeling. Through in-depth analysis and comparative analysis of these cases, the advantages and disadvantages of different designs can be comprehensively understood, providing valuable reference and inspiration for further research and innovative design.

Case analysis method: through in-depth analysis of typical cases of domestic and foreign driverless car styling design, comparing the excellent designs, and exploring their features and points in detail. On this basis, the innovative elements in these cases are summarized, and the core concepts, key functions, and user requirements of the designs are refined. Through screening and filtering, those inapplicable or inefficient design elements are discarded, to provide a more deep analysis of the key points and essence of the design.

### 1.4 Research Content and Frame

This study collected and synthesized literature on the styling design of unmanned vehicles both locally and internationally, thoroughly examining the historical development, current status, and research dynamics of this field. This review summarizes the theoretical and empirical research results of previous research, examining the styling design of early automobiles, identifying the design characteristics of classic models, and exploring the impact of technological progress, changing consumer demand, intelligence, and electrification on the styling design of the car body. It further analyzes the new styling needs of driverless technology, the design specific to electric models, and the differences in design under the convergence of different geographical and cultural backgrounds. In addition, the possibility of integrating traditional cultural elements with modern design is explored. Through the analysis of practical cases, we summarize their concepts and functional designs and the needs of resource conservation and environmental protection. To provide theoretical support for the future development of unmanned vehicle styling design under the guidance of innovative methodologies such as the theory of topology, artificial intelligence, and deep learning-assisted design.

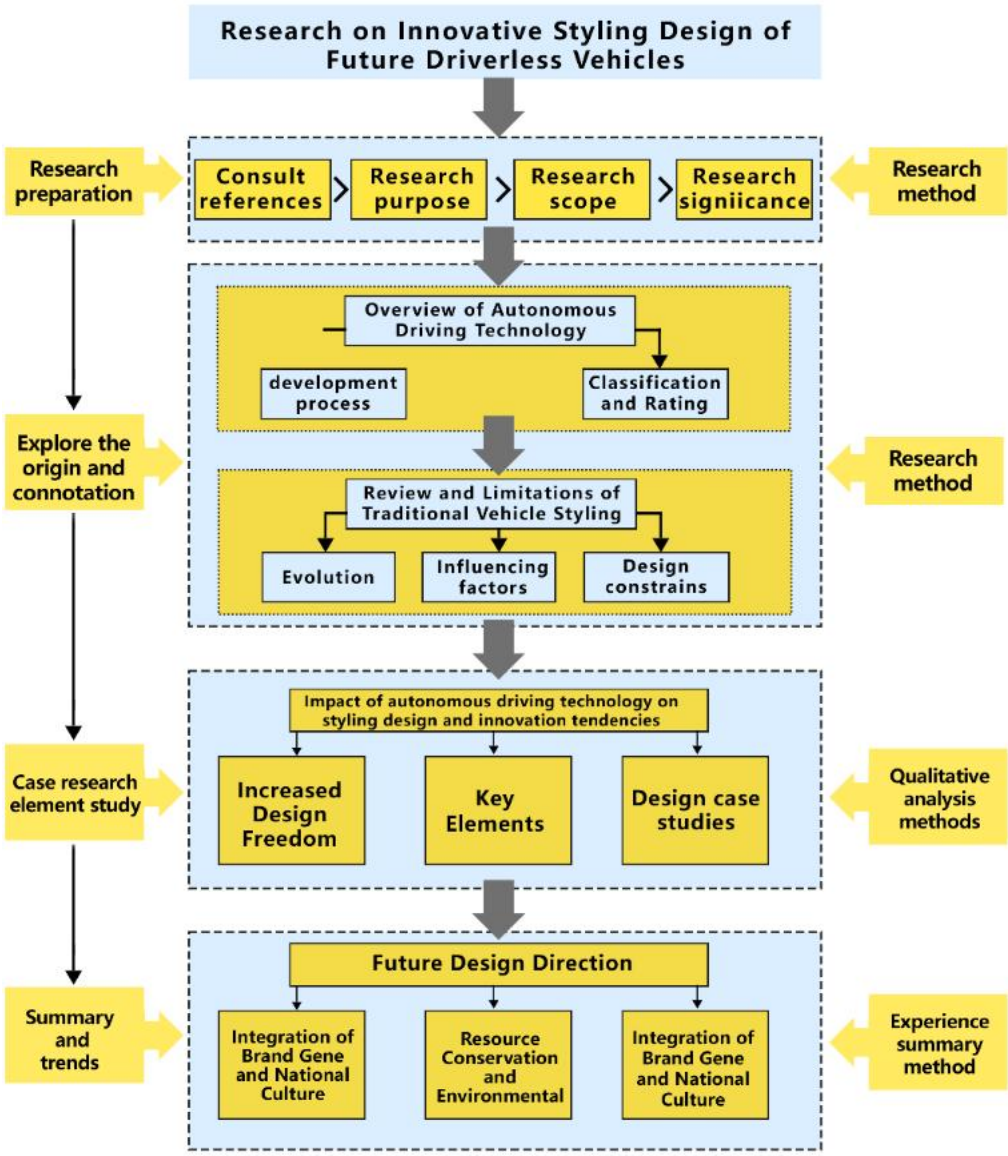



Figure 2: Frame diagram

**2. Literature Review**

Focusing on driverless vehicle styling design, this literature review systematically analyzes recent academic research, screens key points of driverless vehicle design and technological innovation, and identifies research limitations. The review covers everything from exterior simplification to color and material innovation and emphasizes the importance of user-centered design and sustainability principles to provide theoretical support and guidance for future research directions.

**2.1 Domestic and International Research Status**

Chenguang Shang (2020) states that advances in driverless technology offer new degrees of freedom in automotive design, making design more focused on space and the ride experience, and emphasizing the importance of systematic design. Chao Huang (2017) explores how driverlessness has led to cleaner, sleeker styling and expanded interior space while mentioning the impact of the application of virtual technology and globalization on design. Tang Yin (2023) emphasizes the importance of exterior design, interiors, and color schemes and points out how new energy technologies open up a new era of automotive design, mentioning the design innovations of Tesla and Build Your Dream Your Dreams (BYD) companies. Wenhui Zhang (2021) analyzes the design needs of new energy vehicles, especially mini-vehicles, and proposes a styling solution that combines environmental protection and humanized design concepts, which are recognized by consumers. Yun Zhang and Muyin Chen (2023) discuss the far-reaching impact of new energy technologies on automotive design, emphasizing the need for design to adapt to new power modes, balance traditional aesthetics, and look ahead to the challenges and trends of new energy vehicle design.

Lanre-Amos (2015) introduced an innovative design concept for autonomous vehicles that addresses the unique opportunities presented by the rapid advancement of self-driving technology. Ge and Li (2021) delve into strategies and developments in the innovative exterior design of New Energy Vehicles (NEVs). O'Reilly and Göransson (2016) note that design choices are influenced by rational and irrational factors, including vehicle aesthetics. Narayani and Kumar (2021) explore the potential of autonomous vehicles to reduce carbon emissions and improve energy efficiency, underscoring the critical role of design in achieving sustainable mobility solutions.

Table 1: Summary of Literature Studies Abroad

| Research Direction | Reference | Trait |
|---|---|---|
| New Energy Vehicles (NEVs) Styling and Design Innovation | Discussion on the innovation of new energy vehicle exterior design; Exploration of future automotive design trends; Importance and development of conceptual vehicle design; Driverless vehicle interior design based on the theory of topology; Research on automotive exterior design in the context of localization; Research on the logo design of China's independent automotive brands; Influence of minimalist design on the trend of styling design of new energy vehicles; Research on the evolution of automotive styling design styles. | Autonomous driving and new energy technologies are driving automotive design towards simplicity, eco-friendliness, and personalization, incorporating innovative technologies to meet diverse needs. |
| Behavior and interaction design for self-driving cars | Driving style: How should an automated vehicle behave?<br>Exploration of a provisional design for the future autonomous vehicle. | Self-driving car designs that blend innovative technology and aesthetics are reshaping urban mobility and the user experience. |

| | | |
|---|---|---|
| Artificial Intelligence and Design Methods | A Review of Artificial Intelligence-Assisted Vehicle Styling Design Methods.<br>Approaches to Automotive Design with Artificial Intelligence Intervention | Artificial intelligence is driving automotive design towards greater efficiency and innovation, enhancing the design process and product innovation through technology integration. |
| Research on Automotive Technical Standards and Policies | Analysis of the Automated Vehicle Driving Classification Standard | A detailed classification of automotive automation levels was made and compared with international standards to promote the standardization of the smart car industry. |

In summary, existing research has certain limitations in the field of driverless car styling design, which are mainly manifested in the lack of a comprehensive balance between technological implementation, market positioning, user experience, and aesthetic needs, as well as the lack of a comprehensive analysis of the needs of different markets and user groups, especially in the exploration of globalization and multicultural integration. Meanwhile, existing research fails to fully utilize emerging technologies such as artificial intelligence and deep learning for driverless design innovation, and lacks in-depth exploration of the application of new materials and manufacturing processes in styling design. Going forward, research should consider more comprehensively the various factors in the styling design of unmanned vehicles, strengthen interdisciplinary research, and actively adopt advanced technologies to improve design efficiency and personalization. In addition, research needs to explore in depth the application of new materials and processes, pay attention to the diversity of global market demands, and emphasize the potential of driverless cars to promote sustainable development of society to achieve more environmentally friendly, energy-saving, and intelligent transportation solutions.

## 3. Overview of Driverless Technology

### 3.1 The Evolution of Driverless Technology

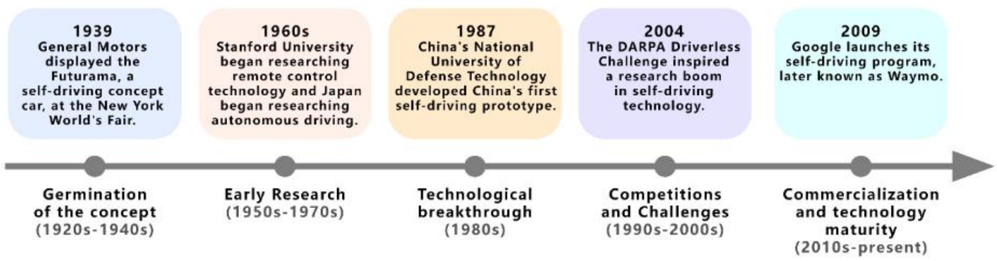



Figure 2: A brief history of driverless technology

The development of driverless technology can be traced back to conceptual ideas in the early 1900s, with Francis P. Houdina demonstrating radio-controlled cars in 1925, and General Motors' Futurama concept car in 1939 furthering the public's understanding of driverlessness. In the 1950s, induction cable technology was proposed, followed by remote control and machine vision research at Stanford University and Japanese research institutes in the 1960s. By the 1980s, research in Japan and China advanced the practical application of driverless technology, and in 1995, Carnegie Mellon University's NavLab program demonstrated the feasibility of driverless technology (Wu, 2019). Into the 21st century, the Defense Advanced Research Projects Agency (DARPA) challenge and the 2009 Google Waymo project drove the commercialization of driverless technology. Driverless technology is realizing the transition to a fully automated intelligent transportation system through deep learning, multi-sensor fusion, and the Internet of Vehicles. This transformation heralds a fundamental change in the transportation model. Driverless technology is a concentrated manifestation of transportation automation and intelligence. It is in the evolutionary stage from partially automated driving (L1/L2 level) to conditionally unmanned driving (L3 level), and is constantly exploring the realization of highly unmanned driving (L4 level) and completely unmanned driving (L5 level) advanced forms. In this process, the integrated application of cutting-edge technologies, such as deep learning, multi-sensor fusion technology, and high-precision maps, significantly improves the performance of unmanned systems in terms of environment perception, decision planning, and execution control.

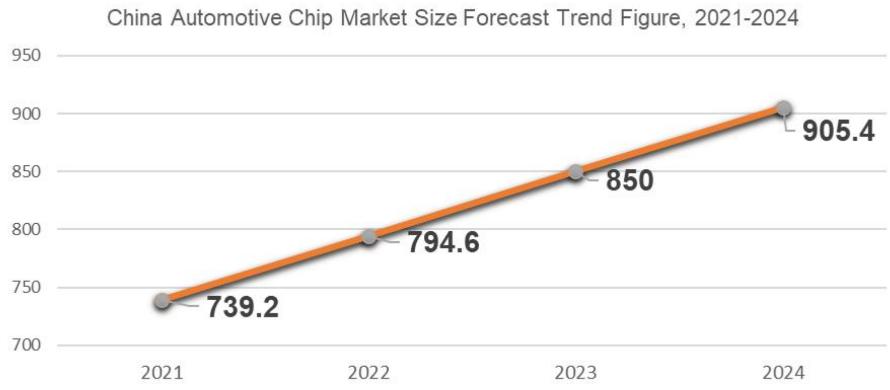



Figure 3: China Automotive Chip Market Size

The continued expansion of China's driverless market, which is expected to grow from 11.85 billion yuan in 2023 to 120.68 billion yuan in 2029, signals that the commercial application of driverless technology will be industrialized on a large scale in a variety of fields, including public transportation, cabs, logistics, and distribution. Meanwhile, it is predicted that China's automotive chip market is expected to reach 90.54 billion yuan in 2024, providing strong computing support for driverless cars. Driverless cars are considered one of the important directions for future automotive development, which will provide humans with a safer, environmentally friendly, and comfortable way to travel (Hu & Deng, 2020). In this context, the Chinese government attaches great importance to the development of driverless technology. It provides strategic guidance and legal protection for the development of intelligent connected vehicles through a series of policy documents, such as Made in China 2025 and the New Generation Artificial Intelligence Development Plan.

### 3.2 Classification and Rating of Unmanned Technologies

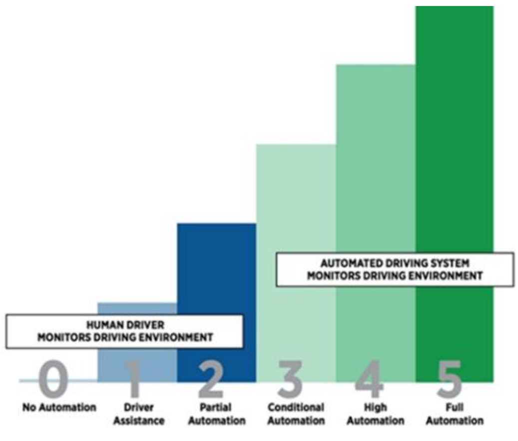



Figure 4: Driverless classification

In 2016, the Society of Automotive Engineers (SAE) defined 6 levels of driverless, from 0 (fully manual) to 5 (completely driverless), as shown in Figure 2. These level definitions are also adopted and recognized by the U.S. Department of Transportation. Most cars on the road today are level L0: manually controlled. For example: in emergency braking systems, the L1 level of driverlessness is the lowest and is characterized by the fact that it is equipped with a simple automated system to assist the driver, a system that helps the vehicle maintain a safe distance from the car in front of it. The L2 has a more advanced driver assistance system, where the car can control steering, acceleration, and deceleration. According to Hu & Deng (2020), the L0 to L2 systems are advanced driver assistance systems but still rely on the traditional driver for driving duties, with the driver automation system only providing driving assistance. The technological leap from L2 to L3 is significant, but the change is not as obvious to the driver. While L3 cars can sense their environment and make more informed decisions, drivers must still be ready to take over. The key difference between L3 and L4 driverlessness is the ability of L4 vehicles to intervene in the event of a malfunction or system failure, however, until regulations are improved, the vehicle is subject to the same rules and regulations as the traditional driver, with the driver automation system only assisting the driver. However, until regulations are perfected, vehicles are limited by geo-fencing (people can only drive within a certain range and generally at speeds of up to 30 kilometers per hour). So most L4s are shared mobility. L5 driverless cars do not require a driver to operate them, meaning that the “dynamic driving task” is eliminated. L5 cars are in the fully automated stage, where the passenger chooses the destination and the system decides and drives without human intervention. L5 vehicles have been tested in many locations around the world, but to date, they have not been used in any way and none of them have been truly driverless.

## 4. Review and Limitations of Traditional Automotive Styling

This chapter will discuss the application of theories related to automotive personalized HMI design, introduce the application of user experience design theory and cognitive psychology in HMI design, and explore the interaction design strategy that combines the two. By analyzing the application of design methods in automotive HMI design, the design strategy and development direction of personalized HMI design will be studied.

### 4.1 The Evolution of Automotive Styling

Table 2: A Brief History of Automotive Design

| Periods | Design Characteristics | Representative Model | Design Concepts |
| --- | --- | --- | --- |
| Initial Development | Utilitarianism is paramount, emphasizing ease of production and functionality |  1915 Ford Model T | Horse-drawn carriages to automobiles, boxy structures, function above all else |
| Early to mid-20th century | Pursuing streamlined design, reducing wind resistance, and increasing speed |  1930s Beetle-type sedan | Aerodynamic and aesthetic challenges |

| | | | |
|---|---|---|---|
| Late 20th Century | Diversification and customization, miniaturization, and energy saving |  1970s Minivan | Energy crisis and environmental issues, meeting individual needs |
| 21st Century | Globalization and intelligence, integration of multicultural elements, and new opportunities brought by intelligent technology |  Buick MPV | Global market demands, impact of autonomous driving technology |
| Rise of driverless cars | Combination of aesthetics and functionality, integration of advanced sensors and computing units, and other technological equipment |  Airport driverless cars | Maintaining aesthetic qualities and integrating emerging technologies |

The history of automotive styling is the product of a combination of technological innovation and aesthetic pursuits. From the box-type sedan in the early 20th century to the Beetle-type in the 1930s, to the fish-type sedan in the 1950s, each change was a challenge to aerodynamics and aesthetic concepts. In 1915, Ford's Model T led the way with its simple box-type design, and in the 1970s, the emergence of the wedge-shaped car foreshadowed the direction of modern automobile design (Huang, 2017). With the technological constraints of the times and the intensification of market competition, automobile exterior design experienced a shift from 'industrial horse-drawn carriages' to low-wind-resistance streamlined styling (Zhang & Chen, 2023). The design of driverless cars inherits this historical lineage while incorporating elements of smart technology to show a new face of future transportation.

### 4.2 Influences on Traditional Automotive Styling Design

*4.2.1Aesthetic Characteristics of Traditional Automobile Styling*

In automobile styling design, the integration of aesthetic features is crucial, including the balance between functionality and aesthetics, the harmony between static and dynamic, and the combination of rationality and sensibility. These features require designers to comprehensively consider the multi-dimensional aesthetic elements of the car, such as structural characteristics and emotional expression, in the design process.

*4.2.2Basic Factors of Design Aesthetics*

The basic factors affecting the aesthetics of automobile styling design include artistry (form, color, texture, and optical effects), technology (ergonomics, aerodynamics), economy (value engineering), and material (types, characteristics, and trends). Together, these factors shape the foundation of automotive styling design and have a profound impact on its aesthetic expression.

*4.2.3Laws of Design Aesthetics and Creative Thinking Methods.*

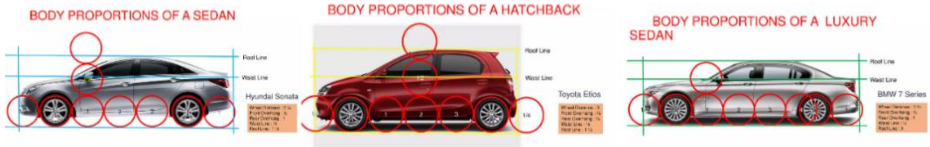



Figure 6: Automotive proportion

Automobile styling design should follow a series of aesthetic laws, such as change and unity, balance and stability, contrast and harmony, etc., of which proportion is the core. Proportion not only determines the aesthetics of the car's appearance but also affects its functionality and practicality. Designers need to seek the balance of proportions in static and dynamic and consider the visual proportional effect of the car at different speeds and postures. In modern automobile design, the innovation of proportion is the key to realizing individualization and differentiation. Designers can adjust the proportion relationship, such as shortening the front overhang, lengthening the rear overhang, or adjusting the height of the car body, to create a unique visual effect and improve the recognition of the car.

### 4.3 Limitations of Conventional Automotive Styling

Traditional automotive styling design is constrained by multiple factors that, together, shape the boundaries and framework of automotive design. At the technical level, the layout of the internal combustion engine, the mechanical structure, and the powertrain form the basic constraints of the design, of which the position and size of the engine play a decisive role in the vehicle form and the layout of the interior space. At the regulatory level, vehicle styling is subject to strict safety and dimensional standards, such as China's GB 1589 standard for external dimensions and GB 11566 standard for external projections, which impose clear legal constraints on vehicle exterior design. Market factors also influence and constrain styling design. Consumers' established aesthetic habits and market demand expectations have an indirect but far-reaching impact on designers' creativity, especially when traditional automotive aesthetic standards have taken hold. Digitalization, intelligence, and energy changes are driving the evolution of design logic, prompting designers to consider user needs, usage scenarios, and brand strategies beyond the limitations of traditional drawing and size proportions. At the same time, the introduction of new materials and technologies has brought new possibilities to automotive styling design, especially in the field of pure electric vehicles. The simplification and diversification of the body structure driven by electric motors provide designers with a broader creative space, while the application of new technologies and the trend of consumer upgrading have also pushed automotive styling in the direction of a more sensual and free expression. The complexity of the design process itself should not be ignored. Automotive styling design is a systematic process that integrates image thinking and logical thinking and involves multi-programs, multi-processes, and multi-iterative design behaviors, reflecting a high degree of innovation and uncertainty.

## 5. Impact of Driverless Technology on Styling and Innovation Trends

### 5.1 Increased Design Freedom

Driverless technology is driving automobile design into a new era in which pure electric motors replace traditional engines and transmissions, providing greater freedom in styling. Driverless cars driven by electric motors have a greatly simplified body structure with more diverse structural forms and more flexible component arrangements (Li & Wu, 2020). This design change not only eliminates traditional components such as the steering wheel and center console but also enhances the flexibility of the vehicle's internal space layout. It tends to be simple and rounded, with a longer wheelbase, thereby improving passenger space and comfort. At the same time, the curved design of the body is simplified, replacing complex light and shadow effects with simple light bands and color separation treatments to convey a sense of the future. With the shift in operating modes, the interior space of the car is expected to transform into a multifunctional mobile living space, while the exterior form reveals a simpler design language. The application of new materials, such as high-strength steel and lightweight materials, not only improves the safety performance of vehicles but also opens up new possibilities for form design. Driverless technology eliminates the need for traditional front grilles, creating innovative space for the vehicle's front design, and utilizes LEDs and interactive lighting systems to enhance the vehicle's recognition and interactivity. In short, the development of driverless technology has revolutionized automotive design with innovations and breakthroughs.

### 5.2 Key Elements of Future Driverless Vehicle Styling

While appealing to consumers, driverless vehicle styling design must reflect characteristics such as technology and sustainability to build a new styling language system (Tang et al., 2023).

*5.2.1Minimalist Styling Trends*

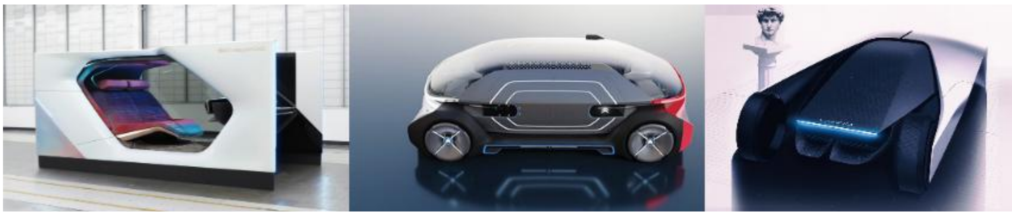


Figure 7: Driverless concept car

The trend of simplicity in the exterior styling of driverless cars is becoming a dominant direction in the industry. The minimalist design emphasizes the removal of superfluous decorations and complex elements in pursuit of simplicity, directness, and functionality to make the design more focused and effective (Liao & Liao, 2023). This trend is reflected in the simplification of body surface design by reducing complex light and shadow relationships in favor of simple light bands and color separation treatments to convey the design language, which not only achieves visual clarity but also reduces production and maintenance costs. Future automotive styling design will prioritize functionality, with the passenger experience at its core, optimizing the layout of the entire vehicle to improve travel efficiency. This design concept, which focuses on practicality and passenger experience, demonstrates the pursuit of efficient travel by driverless cars. The rise of integrated body modeling now emphasizes clean contours and curved surface design while also focusing on providing a humanized and comfortable ride experience, which not only enhances the aesthetics of the vehicle but also improves brand recognition, reflecting the wholeness and coordination of driverless car design. Taken as a whole, the exterior design of driverless cars demonstrates a new design concept that is user-centered and emphasizes both technology and aesthetics through the integration of simplicity, functionality, and integration.

*5.2.2Innovative Applications of Innovative Materials*

Table 3: Examples of innovative material applications

| Model | Material | Function |
| --- | --- | --- |
|  Vision EQS | Smart Glass Technology | Provides privacy and anti-glare features |

| | | |
|---|---|---|
|  BMW i Vision Dynamics Concept | Carbon Fibre Reinforced Plastic (CFRP) | Reduce body weight while maintaining structural strength and rigidity for energy efficiency and dynamic performance. |
|  BMW iX Flow Concept | Electronic ink (E-ink) technology | Every inch of the car's "skin" switches between black, white, and grey at the same time. |

The Mercedes-Benz Vision EQS Concept demonstrates a smart glass technology that allows the windows to switch between transparent and opaque, providing privacy protection and anti-glare features. This dimming glass technology utilizes liquid crystal materials to regulate light by controlling the arrangement of liquid crystal molecules with an electric current. Ford Fusion utilizes a special self-repairing material that is designed to automatically restore itself after minor scratches or dents. The material contains microcapsules which, when the surface of the car is damaged, rupture to release a restorative agent that fills the scratch and cures it, allowing it to repair itself. The Renault Symbioz concept car showcases an intelligent styling design with integrated sensors and displays on the surface of the car that can show information about the vehicle's status and interact with the outside world. The design utilizes flexible display materials to provide a new way of interacting with passengers and the environment.

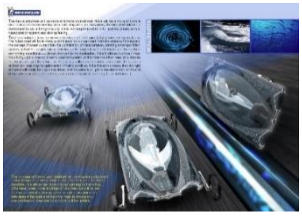
*5.2.3“BOX” Body Styling Trends*

Figure 9: Example of ‘BOX’ styling

Currently, the Box shape design trend for driverless vehicles is dominating the automotive engineering and design field. This design is characterized by its superior interior space efficiency, which provides passengers with a spacious ride while eliminating the need for a traditional cockpit layout, greatly enhancing the vehicle's versatility and agility; the simplified manufacturing process reduces production costs and improves productivity, while optimized aerodynamic characteristics help reduce energy consumption and increase range; the Box shape's high structural rigidity significantly improves passive safety while facilitating the integration of sensors and cameras without compromising aerodynamics, and its aesthetic uniqueness. The Box shape's high structural rigidity significantly improves passive safety, while facilitating the integration of sensors and cameras without compromising the aerodynamic design. Its aesthetic uniqueness supports brand recognition, in addition, the innovative ride experience and adaptability to different environments indicate that the Box shape design will be the new trend for future urban mobility spaces, especially in the field of shared mobility and public transportation, demonstrating the innovation and adaptability of driverless car design in meeting emerging technologies and market demands. With the advancement of technology and market maturity, this design is expected to play a more critical role in the future transportation field.

### 5.3 Design Case Studies

Table 4: Case Studies

| Vehicle | Concept | Function | User Needs |
|---|---|---|---|
|  Renault Concept Car | A carpooling service instead of city buses. | Sofa-style semi-circular seating, journey information display screen, convenient on/off ramp. | Suitable for individual or group travel, requesting a car via a smartphone app. |
|  Mini Routemaster | Providing an alternative to the Tube and buses for London. | Railing and storage made from recycled materials, book exchange storage bins, group shared social experiences. | Provide a greener, less crowded commute. |
|  AKA2 | Providing compact and flexible commuting services to China's major cities. | Two modes of operation, with the body rotating into a vertical position in autopilot mode, run on a magnetically driven railway system. | Commuter services. |
|  Agora E | A public gathering space that promotes face-to-face socializing. | Circular seating, use of recycled materials, and large glass panels provide natural light and city views. | Rediscover the importance of human interaction in public space. |

Concept driverless cars are selected for case analysis. Conceptual vehicle design emphasizes innovation and foresight, which can not only bring new ideas and design methods for the automotive industry but also new ideas for brand marketing and consumer demand satisfaction, thus analyzing these cases can be more effective in exploring future automotive styling (Zhang & Chen, 2023). Driverless vehicle styling design is influenced by drive technology and ergonomics and needs to be combined with Maslow's demand theory to accurately grasp the user group's mobility needs, functional needs, and emotional needs (Zhang, 2024).

## 6. Future Design Directions and Trends

### 6.1 Integration of Brand Gene and National Culture

Table 5: Case studies on the integration of national cultures

| Vehicle | Concept | Function |
|---|---|---|

| | | |
|---|---|---|
|  Geely "China Star" Series | Color naming and design with traditional Chinese cultural connotations, such as "celestial blue glaze" and "cuiyu blue". | Drawing inspiration from the aesthetics of "Green" in "A Thousand Miles of Rivers and Mountains", the "Only Green" version of the Star Rui model demonstrates the design aesthetics of "modern technology + traditional culture". |
|  BYD Han | Adopted the "Dragon Face" design language. | This design is inspired by the image of the Chinese dragon, which embodies the authority and honor of Chinese culture. |
|  Chang'an UNI Series | Front "borderless" grille design | Adopting the design concept of "Mass Producer of Future Technology", the design is inspired by the window panes of classical Chinese gardens. |

Automobile styling is an important carrier of automobile brand genes and style expression (Zhang, 2019). The styling design of driverless cars needs to integrate social and cultural factors and market demand in order to realize the harmony and unity of design and culture. While innovating, designers must consider how to integrate brand genes, national culture, and consumer aesthetic trends into automobile design. This response to social culture and market demand not only enriches the connotation of automobile styling but also satisfies consumers' pursuit of personalization and cultural identity. In particular, the integration of brand genes and national culture provides unique perspectives and inspirations for automobile design. Brand gene is a unique cultural characteristic and value concept formed by an enterprise in the process of long-term development, which is an important embodiment of brand personality and competitiveness. In automobile design, the inheritance and innovation of brand genes are the key to enhancing brand recognition and influence. The styling design style of automobiles has become an important means for today's automobile enterprises to enhance their international competitiveness in the context of globalization (Zhong & Yu, 2016). For example, German automobile brands are known for their exquisite manufacturing process and high attention to safety, which is closely related to the pursuit of quality and reliability of the Germans. In contrast, Chinese automobile brands can enhance the cultural connotation and characteristics of their brands by exploring and integrating traditional Chinese cultural elements, such as calligraphy, painting, and architecture. For example, the body design of the Red Flag H5 Red Flag sedan combined with the localization context should be analyzed and designed based on national culture and combined with perceptual engineering (Wu, 2021). The integration of national culture provides rich creative resources and forms of expression for automobile design. The national cultures of different countries and regions have unique aesthetic concepts and expression methods, and the integration of these elements into automobile design not only enhances the cultural value and artistic charm of the products but also satisfies consumers' demand for personalization and differentiation. For example, some Chinese auto brands have started incorporating Chinese elements into their auto styling design.

These elements include the use of Chinese knots, cloud patterns, and other traditional patterns, as well as the use of Chinese red, black, and other traditional colors, all aimed at showcasing the unique charm of the Chinese brand. The integration of brand genes and national culture provides a broad space and possibility for future driverless car styling innovation and design. Designers need to deeply explore and understand the design concepts and elements of different cultural backgrounds, integrate them with modern automobile design, and create automobile styling with both brand characteristics and cultural connotations. Furthermore, to satisfy the diversified needs of the market and consumers and provide a reference study for Chinese automobile design in the refinement and continuation of styling features and the formation of national brand automobiles with Chinese styles.

### 6.2 Design Considerations for Resource Conservation and Environmental Protection

The styling of future driverless vehicles is gradually incorporating socio-cultural and market factors, especially resource conservation and environmental protection considerations, which have become key factors of design innovation. Designers are adopting lightweight materials, optimizing aerodynamic shapes to reduce energy consumption, using environmentally friendly materials to reduce environmental impact, and integrating intelligent systems to improve energy efficiency. The modular design not only extends the service life of the vehicle but also facilitates upgrades and maintenance, while the green manufacturing process and adaptive design ensure that the vehicle is environmentally and culturally appropriate in different regions of the world. In addition, the driverless vehicle's intelligent navigation and sharing features encourage users to adopt more environmentally friendly travel methods, while the brand demonstrates its social responsibility through these eco-friendly designs, enhancing brand value and consumer loyalty. As global environmental policies and regulations become more stringent, driverless vehicles will be designed to be more sustainable and environmentally friendly, leading the way to a greener future of mobility.

### 6.3 Technology Integration and Innovative Design Methods

#### *6.3.1Application of Topology Theory in Automobile Styling Design*

The innovative approach of using topology can effectively solve some complex contradictory problems in driverless vehicle design including the challenge of quantitatively analyzing and evaluating the design options of these vehicles (Wang & Xu, 2022). In the styling design of future driverless vehicles, the application of topology theory represents an innovative design thinking mode, which breaks through the boundaries of traditional automobile design and provides designers with a new problem-solving framework. This theory encourages designers to explore new possibilities through conceptual expansion, functional innovation, morphological evolution, and deepening of design methodology. It promotes cross-border integration, combining technologies from artificial intelligence, human-computer interaction, environmental science, and other fields with automotive design to promote comprehensive design innovation. At the same time, the topology theory also emphasizes the importance of user participation, placing user demands and experience at the center of the design process to ensure that the design outcome meets the actual needs of the market and consumers.

The application of the theory to the styling of driverless cars also focuses on sustainable development and social responsibility. Designers use this theory to explore options for using environmentally friendly materials and energy-saving technologies to minimize the vehicle's impact on the environment, as well as to consider safety and ethical issues in the design to ensure the moral and legal compliance of driverless vehicles. Through this comprehensive and in-depth design approach, driverless vehicles will not only become efficient and intelligent mobility tools, but also mobile spaces that embody the social culture, meet individualized needs, and promote environmental protection. The application of topology theory provides unlimited possibilities for the design of driverless cars, leading to the future development of the automobile design field.

*6.3.2Artificial Intelligence and Deep Learning Assisted Design*

The design has gradually transformed from a marginal auxiliary job in the automotive industry in the early days to a decisive force that is sufficient to dominate the final form of the product nowadays (Wang, 2023). The application of Artificial Intelligence (AI) and Deep Learning technologies in driverless vehicle styling is driving the design process towards automation and personalization. AI algorithms are able to quickly generate design concepts based on user parameters and preferences, enabling highly customized styling. Artificial intelligence-assisted innovative concept design of automobiles is of great significance for the upgrading and transformation of the automobile industry, and for improving product innovation and user experience (Xu, 2021). Toyota, one of the world's largest automakers, utilizes generative AI technology to automate design by incorporating engineering parameters into early design sketches. This technique can help speed up design iterations and improve results. In particular, Generative Adversarial Networks (GANs) show great potential in morphogenesis, creating designs that are both novel and aesthetically pleasing. The AI-assisted design also extends to material selection and process innovation, recommending solutions to achieve lightweight and environmental friendliness. Natural Language Processing (NLP) and computer vision enhance the designer's experience of interacting with the system, while deep learning techniques accelerate design iterations, evaluating the feasibility and aesthetic quality of solutions through machine learning models. Additionally, AI facilitates cross-disciplinary integration to ensure designs meet functionality, safety, and comfort needs and utilizes Virtual Reality (VR) and Augmented Reality (AR) technologies to provide real-time feedback and simulations. Data-driven decision-making supports the prediction of future design trends, while ethical and social responsibility considerations ensure that designs are in line with societal values and sustainability goals.

## 7. Conclusion

This study explores in depth the innovative design paths and trends of driverless vehicle styling and proposes strategies to meet the development requirements of the new era. With the continuous progress of driverless technology and the wide application of new energy technology, the future automobile design brings brand new challenges while increasing the degree of freedom. In addition to body shape and material selection, designers must consider the integration of national culture and the concept of sustainability. The study points out that designers need to make use of advanced technologies such as artificial intelligence and deep learning to improve the intelligence and automation of the design process, achieve personalized customization, and promote the development of automotive styling in the direction of greater efficiency, environmental protection, and humanization. The styling design of driverless vehicles will become a new benchmark for automotive industrial design and lead the development trend of future automotive design. Through the review of existing literature, analysis of design theories, in-depth study of cases, and exploration of user needs, this study provides theoretical support and practical guidance in the field of driverless vehicle styling design and contributes insights of prospective and practical value to the innovative development of the automotive industry.

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