Research on Automatic Driving Mode of Future Transportation

Fuqiong Gao, Ruifan Liu, Sheng Su*
College of Design, Xi'an Technological University, Xi'an, Shaanxi, China
**Corresponding Author.*

Abstract: In recent years, the domestic unmanned technology continues to develop and progress, the driving mode of the vehicle gradually shifted from the traditional manual driving to the development of intelligent driving. This change has gradually reduced the role of drivers in driving. With the passage of time and the continuous improvement of science and technology, we will ultimately achieve the popularization of autonomous driving. A forward-looking concept vehicle is the best way to show people the style concept and development trend of future vehicles. This paper studies the examples of autonomous concept vehicles that have appeared on the market, focusing on grasping the relationship between driver and passenger, expanding the combination of driver and passenger "human-vehicle co-driving". Based on the 'co-driving characteristics' after functional transformation, the optimal design of future intelligent concept cars will be proposed. In the future, it will develop from a simple means of transportation to a comprehensive whole of travel, entertainment and life integration.

Keywords: New Energy Vehicle; Automatic Driving; Human-vehicle Co-driving; Intelligent Interior; Optimal Design

1. Research Background of Unmanned Mode of Future Transportation

1.1 Domestic and International Development Trend and Current Situation

From design to manufacturing, combined with user needs can be seen that the design of self-driving vehicles is a development trend, unmanned vehicles are separated from human driving operations, the overall vehicle design should be considered from a completely new perspective. In recent years, the domestic unmanned technology continues to develop and progress, China's automatic driving is in full bloom, major companies are actively engaged in research and development work on self-driving vehicles. In addition to vehicle companies, other industries such as communications, technology, Internet industry are also actively working to open up new areas related to autonomous driving. Baidu began research and development of "self-driving vehicles" in 2014, and BYD successfully developed China's first self-driving automobile rail transportation system "cloud rail" in 2018.

In other nations, autonomous driving technology is categorized by the Society of American Engineers (SAE) in a published document, which divides autonomous driving into six levels [1]. L0 belongs to the manual driving stage, most of the vehicle configurations on the market currently are in the L2 (partial automation) stage, i.e. they are equipped with advanced assistance systems such as auxiliary lanes, merging assistance, etc. There are already L3 vehicles on the market that can be realized, but they are still a minority.

Since self-driving vehicles originated abroad, Tesla has been applying the "fully self-driving automobile" technology to the extreme long before 2016. Not only Tesla, but also automakers in other countries are following suit to seize this new opportunity brought by the changing development of the industry, and Google is also actively researching and testing the self-driving automobile technology, which also reflects the fast speed and wide range of the development of self-driving automobile in other countries.

1.2 Future Unmanned Design Analysis

The exchange and sharing of intelligent information among vehicles, people and roads is an important node in the evolution of the ‘man-machine-driving’ relationship from a tool to a partner [2]. With the sedentary nature of people's daily life, long driving time makes

the seat gradually become the longest use of the product, the reasonable seat structure design becomes particularly critical. From the perspective of an optimal point of view, the most suitable is the intelligent technology platform, the best carrier of intelligent technology is also the electrification platform, so in the electrification based on accelerating the intelligent further let the intelligent and electrification of the fusion.

In the 'Study on Purchase Intention of Unmanned Vehicles', the authors established a framework model based on the structural equation of perceived benefit-perceived risk, and introduced the two subconscious variables of technological interest and enjoyment of driving into the purchase intention of unmanned vehicles [3]. As a result of the study, it was found that:

Firstly, consumers' purchase intention will have a negative impact on the perceived risk and a more pronounced positive impact on the perceived benefit. Where self-driving vehicles can provide users with usage benefits, enjoyment benefits, and emotional benefits, all have a positive effect on purchase intentions.

Secondly, technological benefits have a significant impact on drivers' perceived benefits, driving pleasure, and willingness to buy, but driving pleasure has little impact on willingness to buy and perceived benefits; technological advances have made the vehicle's driving technology more and more intelligent and user-friendly, and the enthusiasm for self-driving creates a desire to buy, and will not prevent the purchase of a self-driving vehicle because of the loss of driving pleasure.

In the design of the 'human-centred' design idea, we need to consider the use of interests, enjoyment interests, emotional interests and other perspectives, focusing on the use of experience and driving pleasure, can design the steering wheel, throttle and brake in different use scenarios presented in different states. For example, the steering wheel is retained in the L0 manual driving state, which is a continuation of the original vehicle design. In the L5 fully autonomous driving state, the steering wheel is rotated and retracted to save more space inside the vehicle, thus enhancing the entertainment performance, and the design of the vehicle interior adopts the state-incompatible mode, which also guarantees the safety of the intelligent concept vehicle.

2. Unmanned Models of Future Transport

2.1 Human-vehicle Co-Driving Design Theory

The 'human-vehicle co-driving' system is to control the unmanned vehicle by the driver and the control system of the intelligent vehicle, so that the two phases are in a coexisting state, and the intelligent robot and the human are jointly manipulating the vehicle, and in such a driving environment, the manual and the autopilot are automatically switched [4].

The 'man-machine co-driving' system in the control of the autonomous switching process, there are mandatory and spontaneous situations, can be human initiated entertainment mode state and thus switch to the automatic driving state, but also when the driver's manual driving in the presence of safety hazards of the critical situation and switch to the automatic driving mode. In case of sudden failure or overly complicated driving situation, which is beyond the scope of the system function, the system can issue a request for the driver to assist in the driving operation and take over the driving operation in an emergency.

The development of intelligent vehicles is no longer a simple functional design, it began to develop in the direction of human-computer interaction, and shifted from the traditional R & D test to the integration of virtual and reality. The virtual simulation system is a solution for virtual prototype verification, human-machine relationship analysis and innovative design solutions for the vehicle, presenting the whole process of virtual development system from conceptual design to engineering design to testing and verification in the form of 'human-machine co-driving'.

2.2 Conceptual Design Assisted by the Concept of no Boundaries

'No boundary' originally refers to the concept of garden design focuses on the design and natural environment, so that the boundaries between the design object and the surrounding environment become fuzzy, originally used in architecture and environmental design. Nowadays, the concept of 'no boundary' has

been widely used in various fields, with different connotations, but more blurring of boundaries, integration, penetration and other meanings. Under this concept, the design should also focus on the integration of multiple disciplines and design elements, and the integration of people and the environment, so that the concept vehicle itself is integrated with the environment experienced by the driver and passengers, and through the articulation of the 'human-vehicle co-driving' system to dilute the sense of boundaries, to achieve the effect of no boundaries, and natural.

Combining this with traditional aesthetics breaks down boundaries and focuses on mixing and sustainability. Innovative design combines functionality and aesthetics in a way that is unfettered and unrestricted. In a future-oriented world, vehicles will evolve from simple transport to a comprehensive whole that integrates travel, entertainment and living.

Design without boundaries provides users with a lighter design language and efficient interaction experience, while at the same time conveying the concept of humanity to the driver, allowing them to focus more on their lives and have a good time while driving, bringing a completely different experience to the driver in the simplest way. The New Energy Concept Vehicle will continue to enrich the travelling experience of users with more cutting-edge technologies and entertainment features with its distinctive charm.

3. Functional Layout of Future Intelligent Concept Vehicles

3.1 Enhancement of Human-Machine Co-Driving System

The overall design of the vehicle needs to think from a new perspective, from the design of the vehicle to manufacturing, as well as the needs of the user, it can be seen that the intelligent experience of the automated vehicle is the future direction of development. The L5 level of autonomous driving is called the 'intelligent cabin', in which all the users will become the 'passenger' to the passenger's perspective of human-machine interaction. 'passenger', and human-machine interactions are conducted from the passenger's perspective [5]. Before creating the model, a large frame structure is made, and then the main elements are filled according to the functional requirements. (as shown in Figure 1) Since 5G has the characteristics of high speed and low latency, the real-time feedback information from electronic devices such as CAN and ECU can be monitored and evaluated to accurately determine the vehicle's operating conditions and performance, thus achieving the optimal configuration of the vehicle.

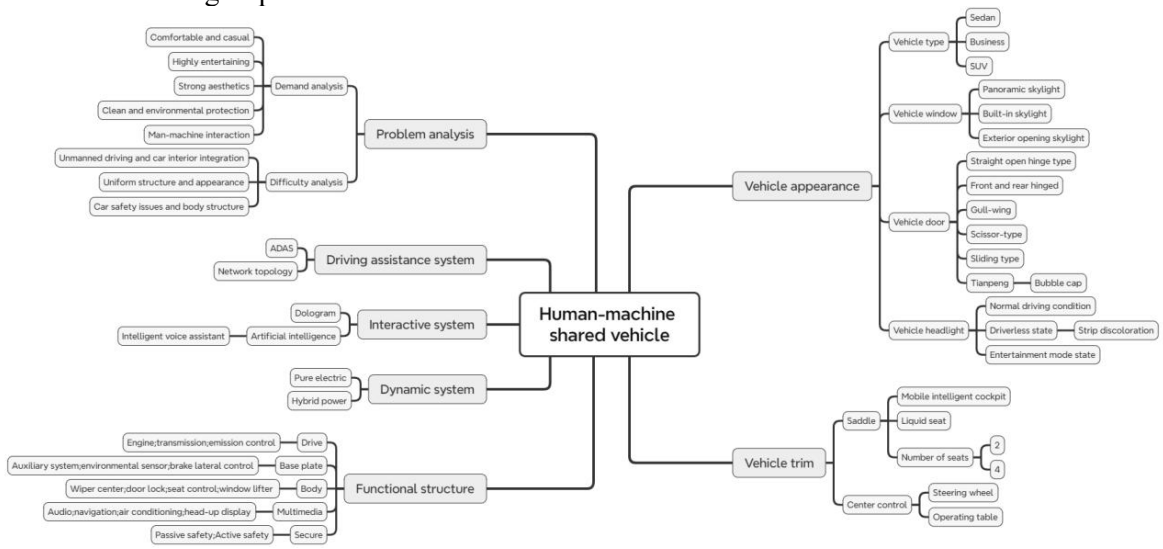

Figure 1. Human-Vehicle Co-Driving System Mind Map

In the process of actual vehicle use, the main control intelligent computer system will work in various modes according to the need to cope with a variety of work situations. Intelligent cockpit system various working modes switching is automatically completed by the software adapted hardware, the hardware design will be based on the corresponding

signal and then switch the corresponding matching power supply configuration. Starting from the three main modules of human-vehicle co-driving, namely driver model, auxiliary driving controller, and human-vehicle cooperative control strategy, the implementation and performance of vertical and horizontal human-vehicle co-driving are studied [6], as follows:

(1) Research on horizontal human-vehicle co-driving control strategy. Aiming at the differences between different styles of drivers on the lateral control, the driver weight penalty method is proposed, firstly, the influence of driver parameters on the lateral control is investigated, and the real-time human-vehicle weights are adjusted according to the path deviation caused by the driver's actual control, and finally, the human-vehicle co-driving strategy verified is adapted to different drivers.

(2) Longitudinal human-vehicle co-driving control strategy research. Driver control in the longitudinal direction always causes energy transfer risks between traffic units, which are related to the distance and speed of traffic units. By analyse the control characteristics of driver's speed and distance in longitudinal direction, consider the coupling relationship between driver and driving environment, and design the effect of man-vehicle co-driving control according to the mean and standard deviation of the risk degree caused by driver's longitudinal control of vehicle.

(3) Research on longitudinal and transverse human-vehicle co-driving control strategies. Aiming at the effect of longitudinal vehicle speed on transverse control, the driver's expectation of speed is considered, which decreases with the increase of road curvature, and a far and near perspective driver model is constructed according to the driver's visual field characteristics in the curved road [7].

3.2 Optimization of shape design under man-machine co-driving characteristics

3.2.1 Vehicle body design features

In the front face shape, the original grille is for heat dissipation, in order to reduce the heat of the engine, some models of new energy vehicles only exist in the electric motor, it is used in the traditional design. The air intake grille part is a more attractive position in the whole shape, the application of autonomous vehicles technology requires infrared sensor monitoring of traffic conditions in the front line of sight, and then the air intake grille has been improved.

The vehicle's body design features a fully transparent insect wing bionic image of the vehicle's door contour. Most of the insect wings have a prism-like crystal surface structure, this unique structure can dispersion and reflection of sunlight, forming a variety of monochromatic light, and then let the eyes to observe the effect of more brilliant [8]. The same elements of the vehicle door bionic, so that the glass from the outside of the vehicle looks more crystal clear, scattering the light emitted by the more diverse range of hues, especially when you open the door after the scissors, the vehicle door from the appearance of the wings like a great insect.

From the point of view of shock absorption, buffer energy-absorbing zone stiffness to be small and deformation to be large, which causes the deformation of the occupant safety zone is small and the energy-absorbing zone of the larger deformation. In order to overcome this problem, the design of the energy-absorbing zone should adopt the structure form of ‘outer flexibility and inner rigidity’, i.e., the buffer energy-absorbing zone and the passenger safety zone should adopt the structure with greater rigidity, while the buffer energy-absorbing zone periphery adopts the structure with lower rigidity and better energy absorption. Due to the limitation of the structural characteristics of the vehicle, the impact performance of the energy-absorbing buffer zone in the lateral and upper part of the collision performance is relatively weak, while in the front and rear collision shows a good anti-collision performance.

3.2.2 Centre control design features

The steering wheel, as the most important part of the centre control operation and human-vehicle interaction, is designed as a retractable and collapsible steering wheel in order to increase the distance between the driver's legs and the steering wheel to increase the comfort experience of the driver and passengers. By establishing three states: autonomous driving mode state, assisted driving mode state and active driving mode state [2]. As the most important part of the centre control area, the steering wheel presents different states when facing three different driving situations.

The higher the degree of automatic driving mode, the greater the magnitude of the steering wheel retracting inwards. The steering wheel is retracted inward by initially rotating 180 degrees with the connecting rod as the centre axis, and then folding backward and upward for contraction. By being able to provide central control interface and instrument display, holographic projection and other simplified information layers, a complete vehicle system is constructed, while the central control design is also closely integrated with the exterior design. For example, Figure 2 shows the contraction of the steering wheel in the state of fully-automatic driving and semi-automatic driving:

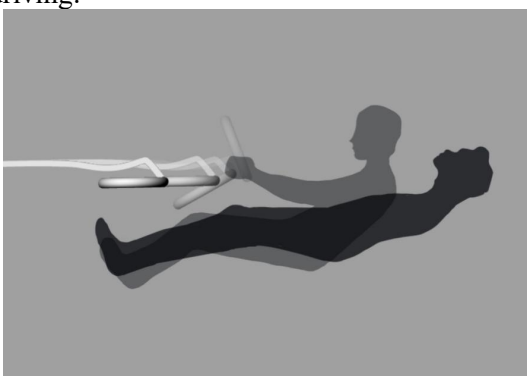

Figure 2. Sketch of Steering Wheel Shrinkage

3.2.3 Cockpit design features

The seat of the cockpit is the object that the driver contacts for a long time in the operation process, and it is also the carrier that reflects the performance and styling design of the vehicle [9]. People will be more inclined to move closer to the window and look out of the window when their sense of driving is reduced, and the vehicle will also form a feedback to stimulate the nerves and help the driver's attention to be excited through the blue light and the seats that fit the human body's comfortable curves more closely. When the driver is judged to be on edge, the interior of the vehicle can create visual and tactile feedback with warm coloured light and soothing elasticated seats that can relax the driver. A horizontal vehicle seat is more likely to prevent low back pain and provide a physical and mental stretch. In an unnatural posture, the pressure difference caused by uneven pressure within the discs can squeeze the lumbar vertebrae and compress the lumbar spine, leading to discomfort such as lumbar soreness and fatigue.

3.2.4 Light strip holographic imaging technology

Holographic imaging technology is a kind of interference, bypass as the basic principle, the object to be measured three-dimensional imaging method. ‘Holography’ is also known as “all the information”, that is, the use of projection equipment to record and reproduce the object being photographed all the light. Holography, also known as ‘virtual imaging’, or so-called ‘hologram’, refers to the use of light interference to capture the position and amplitude of the subject, and to present an image of the subject in the form of a wrap-around projection [10]. By using holography, the subject can be imaged in three dimensions. Through the use of hologram technology to show the effect of the car in different states, two light strips are located on both sides of the roof of the vehicle, from the headlights to the rear part of the vehicle, and the other four ring light strips are located in the articulation of the four wheels, four corners of the light emitted to show the effect of the holographic image, so as to make the driving state more intuitive and visually.

4. Conclusion

The main research results of this paper are as follows: investigating and studying the status of the concept vehicle brands designed at China and abroad and the theoretical basis of the design category, researching the modelling and interior design optimization points of the concept vehicle through the ‘human-vehicle co-driving theory’ and ‘borderless design’ to assist the design conception. Combined with the analysis of consumers' willingness to buy in the autonomous vehicles state, the design objective is to enhance “infinite consciousness”, entertainment and human comfort. Whether it is “man-vehicle co-driving” or unmanned driving, the degree of automation and intelligence includes multiple perceptions of the human-computer interaction experience. The degree of automation and the degree of intelligence, which includes multiple sensory human-vehicle interaction experiences, are the basic features of autonomous driving, which is the direction to be grasped in the innovative design. The intelligent concept vehicle of the future as a multifunctional combination of products and nature can be a symbol of sustainable development, so that people's life

and travelling experience can become more perfect.

References

[1] Zhang Yuhang. The origin, current status and outlook of self-driving vehicles. Electronic Technology and Software Engineering.2017(19):109-110

[2] Hao Ruimin. Research on automated driving technology-driven vehicle interior design. Decoration.2018(07):102-105

[3] Jin Xihui, Gan Hongcheng, Guan Jinping, Yin Pei, Che Liping. Research on purchase intention of autonomous vehicles. Science and Technology Management Research, 2021, 41(8): 186-192

[4] Chen Liwei. Human-computer interaction design of unmanned vehicle in intelligent era. Southeast University, 2022

[5] Lai Fei, Huang Chaoqun, Hu Bo. Development and Challenges of Intelligent Vehicle Autonomous Driving Technology. Journal of Southwest University (Natural Science Edition).2019, 41 (08): 124-133.

[6] Tang Huilong. Performance profile and selection of motor controllers used in electric vehicles. Computer Knowledge and Technology.2009, 5 (24): 6904-6906.

[7] Yang Rui. Research on key technology of unmanned driving based on ROS system. Xi'an University of Architecture and Technology, 2023

[8] Li Jingru, Liu Yao. Application of bionic design in modern industrial design. Architecture and Culture, 2019(7):246.

[9] Pan Feng. Research on autonomous vehicle control method based on driver behavioural characteristics. Beijing University of Chemical Technology, 2021

[10] Sun Tao. Design of vehicle appearance recognition system for autonomous vehicles. Vol. 2020(32): 349.

