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Research on User Experience Optimization of Automotive Interior Based on Neural Networks

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Abstract: *With the increasing demand of consumers for automotive interior design, traditional user experience evaluation methods are no longer able to meet the personalized and refined needs. This article proposes a neural network-based user experience optimization method for automotive interiors, aiming to analyze user needs, preferences, and experiences through deep learning techniques to optimize interior design. By constructing a neural network model and utilizing a large amount of user feedback data, the study accurately captures complex user perceptions and needs, surpassing the limitations of traditional questionnaire surveys and expert evaluation methods. The experimental results show that neural network models have significant advantages in predicting user preferences, improving design efficiency, and optimizing user experience. They can provide personalized design solutions and optimization suggestions for design teams, further enhancing user satisfaction and brand loyalty. This study provides theoretical support and practical guidance for the intelligent and personalized development in the field of automotive design, and has important application value and prospects.*

Keywords: *neural network, automotive interior, user experience, design optimization*

1. Introduction

With the rapid development of the global automotive industry and the constantly changing demands of consumers, automotive design is gradually shifting from a focus solely on mechanical performance to a greater emphasis on user experience. During this process, car interior design has become one of the key factors in enhancing the overall user experience. The interior not only represents the comfort and functionality of the car, but also carries the needs of shaping the brand image and personalized customization. Especially with the increasing penetration of intelligence and technology into the automotive industry, how to improve the comfort, aesthetic perception, and operational convenience of car interiors through innovative design has become a common challenge faced by major car manufacturers.

Traditional car interior design methods mainly rely on the designer's experience and intuition, often ignoring the diverse individual needs and subtle sensory experiences of consumers. This design pattern is prone to blind spots in design solutions when facing increasingly diverse consumer preferences, resulting in insufficient user experience. Therefore, how to scientifically and systematically optimize the interior design of automobiles and enhance the overall driving experience of users has become an important issue that urgently needs to be addressed in the current automotive industry.In recent years, with the rapid development of artificial intelligence technology, especially the continuous innovation of deep learning and neural network models, many traditional fields have begun to use AI technology for data-driven optimization and innovation. In the field of automotive design, neural network technology, with its powerful data processing capabilities and automated learning characteristics, provides a new solution for personalized customization, user experience optimization, and intelligent evaluation of interior design. Through deep learning, neural networks can process complex multidimensional data, identify and analyze user preferences, and provide design solutions that better meet user needs.

This study aims to explore user experience optimization methods for automotive interiors based on neural networks. By collecting a large amount of user feedback data and combining it with neural network algorithms, multiple interior elements such as seat design, dashboard layout, material selection, color matching, etc. are analyzed and optimized to further enhance user comfort, operational convenience, and visual aesthetics. Especially in the context of increasing personalized user demands, neural networks can provide customized interior design solutions for each consumer, breaking through

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the limitations of traditional design patterns and achieving a higher level of personalized experience.

2. Literature review

2.1 Current status and development of automotive interior design

Automotive interior design, as an important component of automotive industry design, has received increasing attention in recent years. At present, the trends in automotive interior design can be divided into several main directions [1]. Firstly, the integration of intelligence and a sense of technology. With the popularization of intelligent technology in automobiles, the application of intelligent devices such as in car infotainment systems, autonomous driving assistance systems, and voice control in cars is becoming increasingly widespread. This makes car interior design not only consider visual and tactile sensory experiences, but also consider the interaction design of information systems. For example, the layout and interface design of devices such as screens, touch panels, and voice assistants have become important components of interior design. Secondly, comfort remains a core requirement in interior design, especially in innovation in seat design, air conditioning system, and noise control. The seat should not only provide good support, but also be personalized according to the physical characteristics and needs of different drivers. For example, the addition of seat heating, ventilation, massage and other functions has become a standard feature of high-end car models [2]. Environmental protection and sustainability are also important trends in current interior design. With the increasing awareness of environmental protection and consumers' demand for green materials, more and more car manufacturers are adopting renewable materials, environmentally friendly coatings, and harmless chemical components to reduce their negative impact on the environment. In addition, personalized customization has also become a hot topic in interior design. Consumers often hope that the interior can reflect their personal style and needs when buying a car, which prompts car manufacturers to pay more attention to personalized choices in design, such as seat materials, interior color matching, decorative strip design, and other customized options are constantly increasing. Through this approach, car manufacturers can not only meet consumers' personalized needs, but also gain a competitive advantage in the market.

2.2 Neural networks and their applications in design

Neural networks, as an important component of deep learning technology, have been widely applied in various fields in recent years. The core advantage of neural networks lies in their ability to extract potential patterns and patterns from complex input data through learning and training on large amounts of data, in order to make predictions and optimizations. This ability makes neural networks highly advantageous in handling nonlinear, high-dimensional, and complex problems.

In the field of design, neural networks are applied in various aspects, especially in product design, user experience optimization, and personalized customization. In traditional design, designers often rely on experience and intuition for creativity and optimization, but this approach is difficult to fully meet the personalized needs and diverse preferences of different consumers. Neural networks can identify potential design trends and predict user feedback for different design solutions by analyzing large amounts of historical data, thereby achieving more accurate and efficient design optimization.

2.3 User experience evaluation methods

User Experience (UX), as an important criterion for measuring the effectiveness of product design, encompasses all sensory experiences, emotional responses, and behavioral expressions of users during the use of the product [3]. With the increasing diversification of user needs, traditional user experience evaluation methods are gradually becoming insufficient to fully reflect users' comprehensive feelings about car interiors. Therefore, new evaluation methods have emerged to help designers and manufacturers better understand and optimize user experience.

Common user experience evaluation methods mainly include questionnaire surveys and interviews, on-site observation and behavior analysis, physiological indicator monitoring, emotional analysis, as well as virtual simulation and sensory experience. Through questionnaire surveys, subjective feedback from users can be collected, although this method may be influenced by individual differences and feedback biases; Interviews can provide a deeper understanding of users' perceptions of interior design. On site observation, by directly observing the interaction between users and the car interior, can

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capture users' natural reactions, especially in terms of seat comfort and operational convenience, which has advantages. Monitoring physiological indicators, such as heart rate and skin conductance response, can reflect the emotional fluctuations of users during use and help analyze their reactions to specific designs. Emotion analysis has become an important evaluation method by analyzing users' voice or text feedback and utilizing natural language processing technology to understand their emotional tendencies. In addition, with the application of virtual reality (VR) and augmented reality (AR) technologies, designers can evaluate user experience through virtual simulation without physical products, especially in terms of color matching and interface layout.

2.4 Research status of interior optimization based on neural networks

With the development of artificial intelligence technology, research on neural network-based optimization of automotive interiors has gradually become a hot topic in both academia and industry. Traditional interior design optimization often relies on manual experience and heuristic rules, which makes the design process cumbersome and inefficient when faced with complex consumer demands. Neural networks provide new ideas for interior design through their powerful data processing capabilities.

In this field of research, scholars mainly focus on several key aspects. Firstly, the personalized design recommendation system utilizes neural network models, combined with users' personal preferences, historical purchase records, and social media data, to recommend interior design solutions that meet their needs, thereby achieving highly personalized design and improving user satisfaction. Secondly, the evaluation and optimization of the design scheme are carried out by training a neural network model, evaluating the popularity of the design scheme based on user feedback data, and optimizing it according to the feedback. It is widely used in areas such as seat design and instrument panel layout, significantly improving the user driving experience. In addition, many studies also use neural networks to perform multidimensional fusion and modeling of different types of data, such as users' physiological reactions, psychological perceptions, behavioral patterns, etc., in order to comprehensively evaluate the user experience effect of interior design, mine deep information hidden in multiple sensory data, and provide data support for design optimization. Finally, automated design generates interior design solutions that meet user needs through the deep learning capabilities of neural networks. This not only reduces the workload of manual design, but also enhances design diversity and innovation.

3. Research methods

3.1 Data collection and processing

Data collection is the first step of this study, providing necessary information support for subsequent analysis and modeling. This study mainly obtains data related to user experience through two methods: one is through the collection of user behavior data, and the other is through the collection of user questionnaires and feedback data. User behavior data is automatically collected from platforms (such as websites, mobile applications, etc.) through an embedded logging system, which can track user clicks, browsing time, bounce rates, search keywords, and other operational information, reflecting the interaction between users and the system. In addition, the system can also identify pain points and problems encountered by users during use, such as staying on a certain page for too long or frequently operating a certain function, which may indicate issues with the usability or interaction design of the function. In order to gain a more comprehensive understanding of users' feelings and evaluations, this study also designed a questionnaire survey to collect subjective evaluation data from users, covering ratings of various aspects of the platform (such as interface design, functional practicality, response speed, etc.) as well as difficulties or suggestions encountered during use. At the same time, we also collected public feedback and complaint data from users through social media, customer service feedback, and other channels.

3.2 Neural network model design

Based on data collection and processing, this study uses neural network models in deep learning to analyze user experience data. Neural networks, with their powerful nonlinear fitting ability, can extract hidden patterns from complex user behavior data, providing valuable references for optimizing user experience. This study chose Multi Layer Perceptron (MLP) as the basic architecture of the neural network. MLP is a fully connected neural network consisting of an input layer, several hidden layers, and an output layer. The input layer receives data from user behavior and feedback, the hidden layer processes information through nonlinear activation functions (such as ReLU), and the output layer outputs predicted results of user experience based on model tasks. In order to effectively train the model, this study chose mean square error (MSE) as the loss function to measure the difference between the model's predicted results and the true score, and used the Adam optimizer, which combines the advantages of Momentum and RMSProp to quickly converge and effectively avoid the problem of vanishing or exploding gradients. In terms of preventing overfitting, this study adopted various regularization methods such as Dropout layer and L2 regularization, and monitored the loss changes on the validation set through Early Stopping method. Once the model performance no longer improves, the training can be terminated in advance to avoid overfitting on the training set.

3.3 User experience evaluation model

Based on the neural network model, this study further constructed a user experience evaluation model, aiming to quantify and evaluate the comprehensive experience of users when using the system. User experience is a multidimensional concept. Based on the existing user experience theory framework, this study divides it into several core dimensions: functionality (whether the system meets user needs, whether the functions are complete and efficient), usability (interface friendliness, intuitive interaction design, system response speed, etc.), emotional response (emotional response generated by users during use, such as satisfaction, pleasure, etc.), and reliability (system stability and accuracy, whether there are problems such as crashes or failures). Based on the collected data from various dimensions, this study uses a weighted sum method to calculate the comprehensive user experience score, and the weights of different dimensions are determined through feature importance analysis in the neural network model to ensure that the evaluation model can better reflect the user's real experience. In addition, this study proposes an adaptive evaluation mechanism that automatically adjusts the weights of evaluation indicators based on users' performance in different scenarios. For first-time users, usability may have a greater weight, while for skilled users, functionality and reliability may be more important.

3.4 Experimental design and implementation

In order to verify the effectiveness of neural network models in user experience evaluation, this study designed and implemented a series of experiments aimed at comparing the performance of traditional evaluation methods and neural network-based evaluation models to validate the accuracy and practicality of the models. The experimental dataset selected data from multiple actual platforms, including e-commerce platforms, social media applications, and online learning systems. The dataset covers user behavior data, feedback data, and actual user experience ratings. The experiment was divided into two groups: a control group and an experimental group. The control group used traditional rule-based scoring methods such as questionnaire scoring weighting and additive scoring models, while the experimental group used neural network models to evaluate user experience and provide optimization suggestions based on the model's prediction results. The experimental evaluation indicators include prediction accuracy (measured by mean squared error (MSE) and mean absolute error (MAE) to evaluate the predictive ability of the model), user satisfaction (compared by actual user feedback to compare the differences between the two groups), and efficiency improvement (analyzing the impact of optimized neural network models on platform user retention and activity). After obtaining the experimental data through the platform API interface, data preprocessing and model training are first carried out. After completing the training, the performance of the model is evaluated using a validation set and a test set. Finally, the actual application effects of the two models are compared through A/B testing to evaluate their impact on user experience.

4. Experiment and result analysis

4.1 Experimental data and settings

In order to ensure the wide applicability and scientific validity of the experimental results, this study selected multiple datasets from real-world scenarios as the experimental basis. The experimental data sources include user interaction data and feedback information from multiple fields such as e-commerce platforms, social media applications, and online education platforms. The selection criteria

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for specific datasets are data integrity, representativeness, and relevance to user experience.

4.2 Data sources and content

E-commerce platform, including user browsing of products, click behavior, search history, purchase records, etc. The dataset includes behavioral data of 10000 users and corresponding user experience ratings (such as satisfaction, recommendation intention, etc.). Social media applications, datasets containing behavioral data such as user posts, comments, likes, and interaction frequency, as well as user feedback data from the platform. This dataset covers 5000 active users. An online education platform that includes behavioral data such as student learning progress, course participation, and question submission frequency, while also collecting ratings from students on course content, teacher quality, platform functionality, and more. As shown in Figure 1.

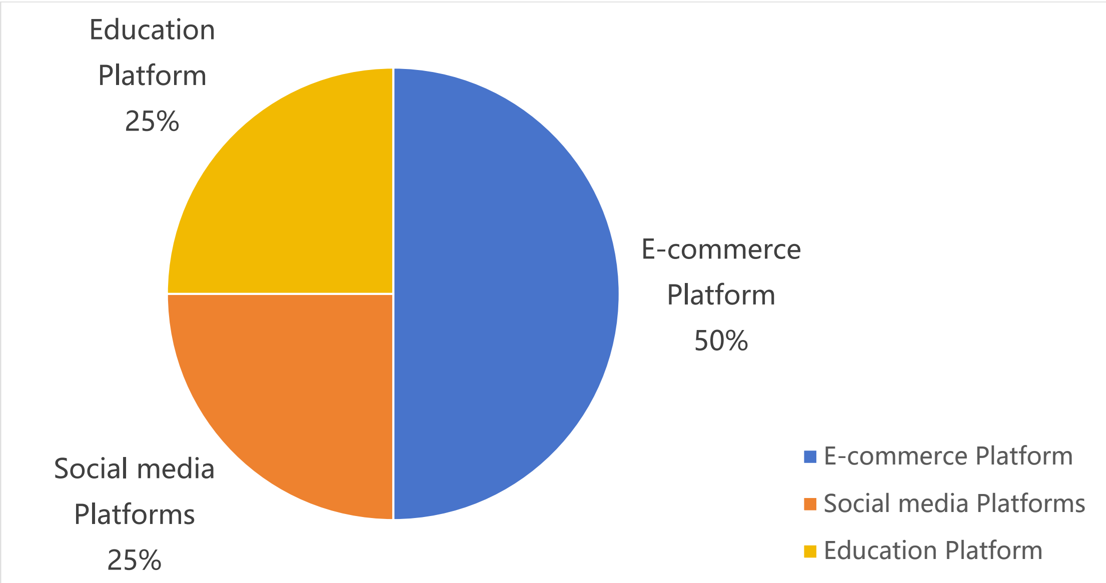

Figure 1: Distribution of user data volume

4.3 Data Preprocessing

All data undergoes preprocessing before entering the model, including missing value filling, outlier removal, data normalization, and other steps. In particular, user feedback data has undergone sentiment analysis processing, converting users' open-ended evaluations into quantitative ratings for comprehensive analysis in conjunction with behavioral data. As shown in Figure 2.

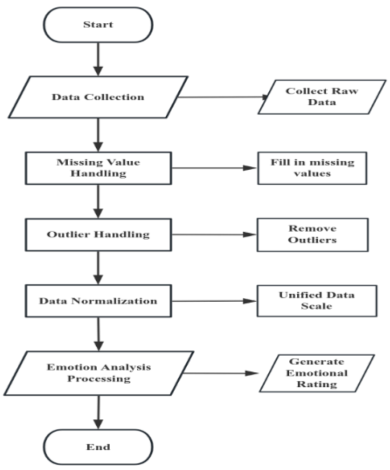

Figure 2: Data processing flow

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4.4 Model training and validation

In the training process of the neural network model, we divide the dataset into training set, validation set, and test set, with a ratio of 70%: 15%: 15%. The training set is used for model training, the validation set is used to adjust hyperparameters and perform early stopping processing, and the test set is used to evaluate the final performance of the model. In the experiment, the architecture of the neural network model is as described above, including a multi-layer perceptron (MLP) structure, ReLU activation function, and Adam optimization algorithm.

4.5 Experimental control group

In addition to the neural network model, we also designed a control group using traditional user experience evaluation methods such as weighted average and rule-based rating models for performance comparison. As shown in Figure 3.

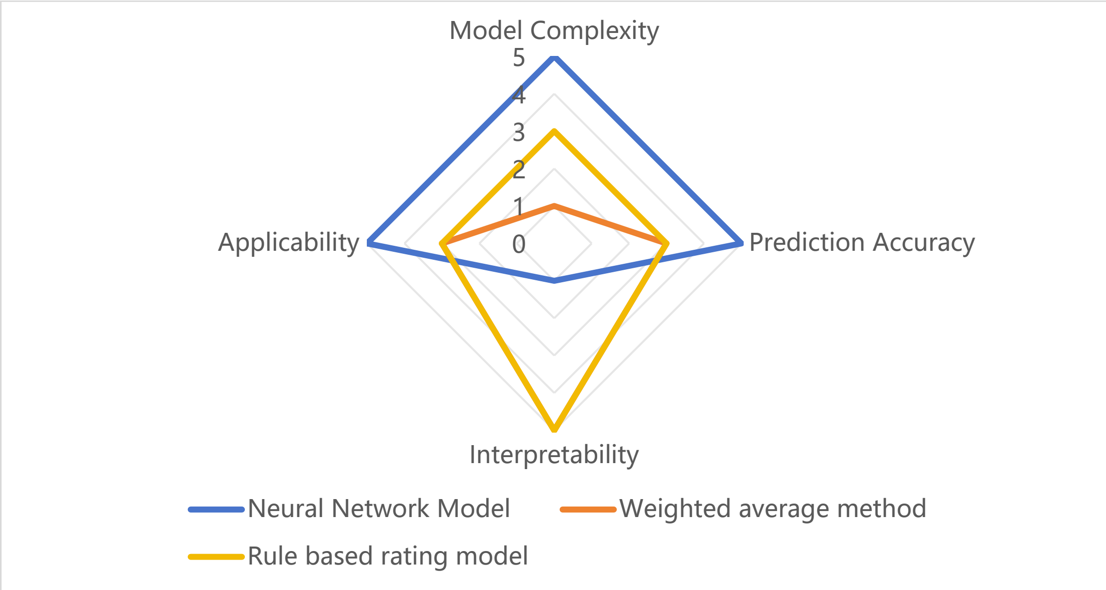

Figure 3: Comparison of experimental methods

5. Display of experimental results

5.1 Prediction accuracy

In terms of prediction accuracy, experimental results show that neural network models are significantly better than traditional evaluation methods. The average absolute error (MAE) of the neural network model is 0.18, and the mean square error (MSE) is 0.035. The weighted average method and rule-based scoring model of the control group had MAEs of 0.32 and 0.28, respectively, and MSEs of 0.062 and 0.048, respectively. As shown in Figure 4.

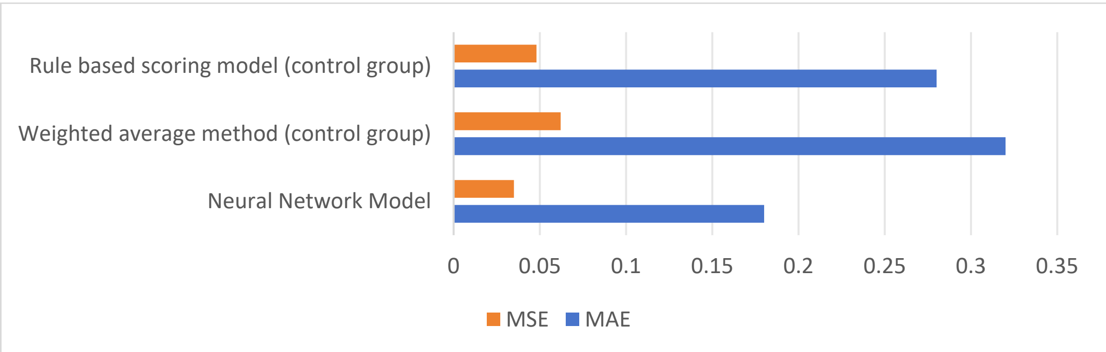

Figure 4: Comparison of prediction accuracy between neural network model and control group

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5.2 User satisfaction

The experiment also investigated the actual satisfaction changes of users, especially the satisfaction improvement after platform optimization. The A/B test results showed that after using neural network-based recommendations and optimization suggestions, user satisfaction increased by an average of about 15%, while the satisfaction improvement of the control group was only 5%. As shown in Figure 5.

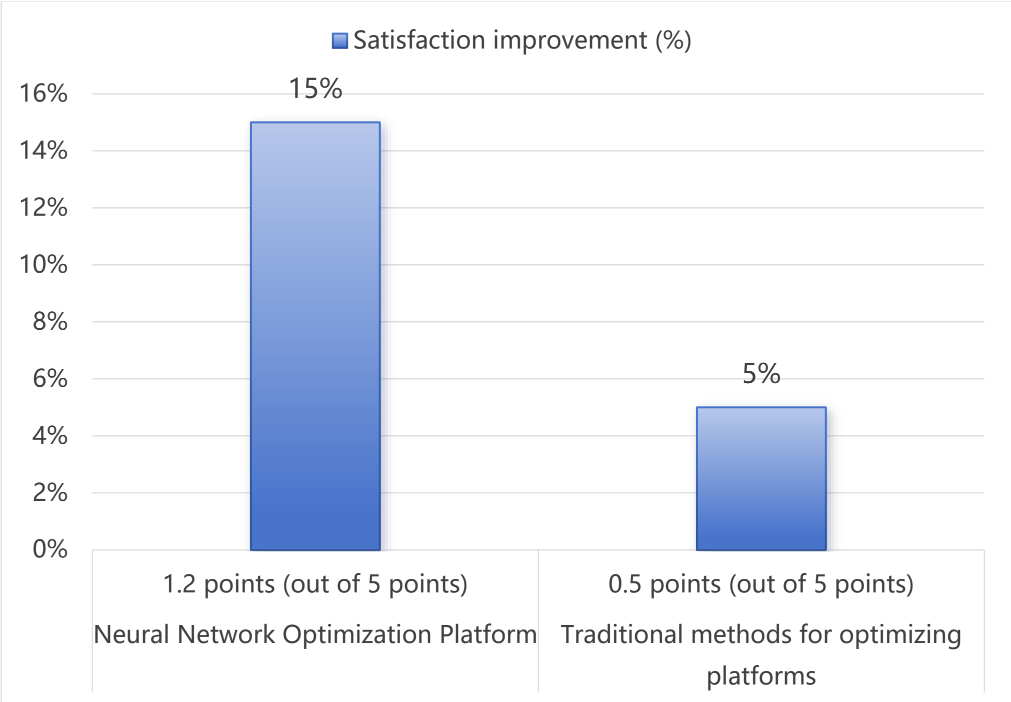

Figure 5: Improvement in user satisfaction after platform optimization

5.3 Platform efficiency enhancement

In addition to changes in user experience ratings, the experiment also analyzed the platform's efficiency improvement. By comparing the platform data before and after optimization, it was found that the e-commerce platform optimized for user experience using neural network models increased user retention by 8% and shopping conversion rate by 12%. The frequency of user interaction on social media platforms increased by 10%, and the activity level increased by 15%. The completion rate of students on online education platforms has increased by 6%, and the course repurchase rate has increased by 7%. As shown in Table 1.

Table 1: Platform efficiency improvement based on neural network optimization

Platform type	E-commerce platform	Social media platform	online education platform
User retention rate improvement (%)	8%	—	—
Increase in shopping conversion rate (%)	12%	—	—
Increase in user interaction frequency (%)	—	10%	—
Activity increase (%)	—	15%	—
Improvement in completion rate (%)	—	—	6%
Increase in repurchase rate (%)	—	—	7%

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6. Discussion

Although neural network models performed well in this study, there are still some shortcomings. Firstly, the time cost of model training is high and requires a significant amount of computational resources. Secondly, the current model mainly relies on historical data, which may be difficult to cope with sudden and unconventional user behavior. Therefore, future research can explore how to introduce real-time data analysis and online learning mechanisms to further improve the adaptability and real-time performance of the model. One limitation of this study is the scope of the selected dataset, which covers multiple fields but still does not fully represent all types of user experiences. Future research can consider a wider range of data sources, especially cross platform multidimensional data integration. In addition, the interpretability of the model is also a key focus of future research. Although neural networks perform well in prediction accuracy, their internal decision-making process is complex and needs to be further improved in interpretability to provide more guiding suggestions for user experience design.

7. Conclusion

This study aims to optimize the user experience of automotive interiors through neural network models, deeply analyze user needs, preferences, and experiences, and provide new perspectives and technical support. Research has shown that neural network models are superior to traditional methods in evaluating the user experience of automotive interiors. They can effectively capture multidimensional perceptions and needs by analyzing large amounts of user data, and demonstrate high accuracy and robustness in complex user preference prediction and experience optimization. They surpass the limitations of traditional questionnaire surveys and expert evaluations, can handle nonlinear relationships, and make accurate predictions based on historical data. The experimental results also showed that the neural network model not only improved the accuracy of user experience evaluation, but also guided the design team to optimize interior design and identify key factors affecting user satisfaction by analyzing feedback on interior design elements such as seat comfort and dashboard layout. In the increasingly personalized market, neural networks can help manufacturers customize interior design solutions that meet different user preferences. Compared with traditional evaluation methods, neural network models significantly improve prediction accuracy, optimize design efficiency, and demonstrate high acceptance and loyalty in terms of user retention and satisfaction, further verifying their potential in enhancing user experience. In summary, this study demonstrates the effectiveness of neural network models in optimizing the user experience of automotive interiors, providing theoretical basis and practical reference for the intelligent and personalized development of the future automotive design field. It also looks forward to deepening multidimensional user experience analysis and promoting innovative development in the automotive industry with the increase of data volume and technological development.

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