Trend Prediction and CAD Application of Interior Design Style Using Big Data

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Abstract. CAD technology can not only improve design efficiency but also make design solutions more intuitive and realistic through technologies such as 3D modelling and virtual reality, making it easier for users to understand and choose. This article proposes a design strategy that combines big data analysis with predicting interior design style trends. Through in-depth mining of massive data, it is possible to reveal the true preferences of users, the evolution patterns of design styles, and potential market demands. Through the application of CAD technology, designers can complete design proposals more quickly and efficiently, reducing design costs and risks. By assigning computing tasks to multiple processing units for simultaneous execution or utilizing specific hardware features for acceleration, this method can complete calculations in a shorter time and further improve response speed. This interior design scheme has achieved significant success in three key areas: functionality, aesthetics, and comfort. This not only reflects the professional competence and design ability of designers but also reflects good communication and cooperation between designers and users.

Keywords: Interior Design; Trend Prediction; Big Data; CAD
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1 INTRODUCTION

In the modern era of information, big data has steadily permeated all aspects of society, serving as a pivotal catalyst for societal advancement and growth. Within the realm of interior design, big data has showcased remarkable promise and worth, particularly in forecasting design style trends and enhancing Computer-Aided Design (CAD) applications. With the continuous development of smart home technology, more and more households are using smart home assistants to manage and control home devices. However, these devices often need to collect users' personal information to achieve personalized services, which has raised concerns about privacy and intrusion issues. Benlian et al. [1] proposed a method to mitigate the invasive impact of smart home assistants by using CAD anthropomorphic intelligent design features. Smart home assistants usually need to collect users' personal information, such as voice commands, lifestyle habits, etc., to achieve personalized services. These pieces of information may be used for advertising, marketing, or other commercial purposes, leading to infringement of user privacy. In addition, smart home assistants may also be attacked by hackers or used for malicious activities such as listening and monitoring, further increasing the security risks for users. Smart home assistants should clearly explain their working principles and data collection situation to users, enhance transparency, and reduce their doubts and concerns. This piece delves into the intricate utilization of big data in anticipating interior design style trends and explores how these insights can be translated into tangible design solutions via CAD technology. This, in turn, offers fresh perspectives and approaches for propelling the interior design industry forward. Amidst the converging forces of globalization and the Internet, individuals' expectations of their indoor surroundings have become increasingly varied and tailored, with escalating demands for innovative design styles.

With the continuous development of Internet of Things technology, smart home systems have become an important component of modern homes. However, traditional smart home control methods often require users to operate through devices such as mobile phones and tablets, which, to some extent, affects the convenience and naturalness of the user experience. To address this issue, Bissoli et al. [2] proposed a human-machine interface based on eye tracking for controlling and monitoring smart homes using the Internet of Things. Eye tracking technology is a technique that utilizes sensors or cameras to monitor and analyze eye movement trajectories. Through eye tracking technology, real-time information such as the user's gaze direction and gaze position can be obtained, thereby achieving the naturalness and intelligence of human-computer interaction. Responsible for receiving data from eye-tracking devices and conducting intelligent analysis and processing based on user visual information. The control system should have efficient algorithms and powerful data processing capabilities to achieve fast response and accurate identification. Connect and integrate smart home devices with control systems through IoT technology. Users can control and monitor smart home devices through eye-tracking devices, achieving natural and intelligent human-computer interaction. Furthermore, the consistent emergence of cutting-edge materials, technologies, and concepts widens the scope of possibilities and options available to interior designers. Nevertheless, this proliferation also poses a challenge: How can designers adeptly grasp design style trends amidst such dynamic landscapes? The advent of big data technology introduces a novel solution to this predicament.

The core of big data technology lies in the collection, storage, processing, and Analysis of massive data. In the field of interior design, these data include user behaviour data, design case data, material supply data, and market demand data. Digital tools have become an indispensable part of the architectural design process. CAD (Computer Aided Design) software, as one of the most representative tools, provides infinite possibilities for architects with its powerful design and visualization functions. However, the impact of this technological advancement on the perception of architectural design is still a question worth exploring. Ceylan [3] delved into the impact of CAD based on digital tool knowledge on perceived changes in architectural design through case studies. The traditional architectural design process requires a lot of manual measurement, drawing, and modification, and CAD technology makes these steps simple, fast, and accurate. Designers can directly design on a computer using CAD software and view the design results in real-time. This technological advancement greatly improves the efficiency and accuracy of design, providing designers with more time and space to explore and try different design ideas. The popularization and application of CAD technology have also brought some challenges to the perception of architectural design. On the one hand, excessive reliance on digital tools may lead to a decrease in the designer's perception of physical space. In CAD design, designers can easily adjust spatial proportions and layouts through digital tools, but this virtual adjustment may lead to designers ignoring the actual sense of space. Through the in-depth mining and Analysis of these data, we can find the laws, trends, and associations hidden behind the data, thus providing strong support for the prediction of design style trends. With the advancement of technology and the improvement of people's living standards, the role of interior design in home life is becoming increasingly prominent. The application of big data has brought new opportunities and challenges to interior design. Chen et al. [4] explored how interior design style affects the improvement of home feel under the drive of big data, as well as the practical application and future development direction of this influence. By collecting and analyzing a large number of user behaviours, preferences, and feedback, designers can more accurately grasp user needs, thereby creating a home environment that is more in line with people's living habits and aesthetic needs. For example, through in-depth Analysis of user living behaviour, designers can plan spatial layout reasonably, optimize residential flow, and thereby improve the comfort and convenience of living. As a core element of interior design, the influence of interior design style on the sense of home cannot be ignored. Different design styles can create different atmospheres and emotional experiences, thereby affecting the psychological feelings and quality of life of residents. In enhancing the sense of home, big data can help designers better understand and grasp the characteristics and applicable scenarios of various design styles. Through big data analysis, designers can more accurately determine which design style is more suitable for a specific user group or living environment, thereby improving the targeted and effective design. This data-based prediction method is more objective, accurate, and reliable than traditional subjective judgment. However, it is not enough to rely solely on big data for style trend prediction. Turning these predictions into actual design schemes and meeting the actual needs of users is another big challenge for the interior design industry. This requires the help of CAD technology. CAD technology not only enhances design productivity and minimizes expenses but also elevates the design scheme's clarity and realism via 3D modelling, virtual reality, and other advanced techniques. This facilitates a seamless comprehension and selection process for users.

By leveraging big data technology, designers gain a precise understanding of design style trends, steering clear of trend blindness and subjective biases. This approach refines the relevance and impact of the design, aligning it more closely with user preferences and market demands. With the rapid development of big data technology, various industries have benefited greatly from it. Especially in the fields of interior design and architecture, the application of big data provides designers with a broader perspective and richer inspiration. Chen et al. [5] explored how to use empowerment algorithms to assist architectural design, especially in exploring interior design styles driven by big data. Firstly, the application of big data in interior design has significant advantages. Due to the involvement of various factors in interior design, such as culture, history, art, technology, etc., the integration and analysis ability of big data can help designers better understand and grasp these factors, thereby creating more distinctive and meaningful designs. Then, we utilized empowerment algorithms to generate multiple sets of interior design solutions automatically based on these features and elements. Big data and empowerment algorithms have enormous potential for application in interior design. Through deep Analysis of big data and automatic generation of empowerment algorithms, we can explore interior design styles more efficiently and accurately, providing more comprehensive and in-depth assistance for architectural design. Moreover, through the use of CAD technology, designers can complete the design scheme more quickly and efficiently and reduce the design cost and risk. This design idea and method of integrating big data and CAD technology not only brings new development opportunities for the interior design industry but also provides inspiration and reference for the innovation of other related industries. This study contains the following innovations:

(1) This article puts forward a design strategy that combines big data analysis with interior design style trend prediction. Through the in-depth mining of massive data, we can reveal the real preferences of users, the evolution law of design style, and the potential demand of the market, and provide more forward-looking guidance for the interior design industry.

(2) In the traditional interior design process, CAD is mainly used to make and present the design scheme. In this article, CAD is not only used for this purpose, but more importantly, it becomes a bridge between big data prediction and actual design schemes so that the prediction results can be quickly and effectively transformed into specific design works.

(3) This article constructs a closed-loop system, including user feedback and market verification. This system ensures that the design scheme can be closely adjusted around the needs of users and market dynamics, thus greatly improving the practicality and market competitiveness of the design.

This article introduces a novel approach that integrates big data with CAD technology. Initially, relevant data from the interior design domain is gathered and analyzed using big data techniques to forecast design style trends. Subsequently, these predictions are translated into tangible design solutions using CAD technology, undergoing refinement and enhancement. Ultimately, user feedback and market validation are incorporated to fine-tune the design, ensuring it aligns with user requirements and market dynamics. The implementation of this methodology elevates the standard of interior design while driving innovation within the industry.

2 RELATED WORK

With the rapid development of artificial intelligence and Internet of Things technology, smart home systems have become an important component of modern homes. Among them, smart meters, as an important tool for energy management, are of great significance in improving energy utilization efficiency and reducing energy consumption. Chen et al. [6] explored how to design and implement cloud analysis-assisted smart meters, utilize advanced artificial intelligence technology for demand side management of smart homes, and achieve optimized energy utilization. By using machine learning algorithms, the operational status of smart meters can be monitored and predicted, potential faults can be detected in advance, and maintenance can be carried out to improve the reliability and stability of the equipment. Using artificial intelligence technology to conduct in-depth Analysis of household electricity consumption data, understand user electricity habits and needs, arrange the running time of household electricity equipment reasonably, and optimize energy use. By analyzing user electricity consumption data, understanding their electricity consumption behaviour and habits, and providing a basis for optimizing and personalized recommendations of smart home devices. Using edge computing technology to transfer data processing and analysis tasks to the device edge, reducing the burden on cloud servers and improving the speed and efficiency of data processing. With the advent of the big data era, the position of visual needs in interior design is increasingly prominent. How to use big data to drive simulation of interior design styles and meet visual needs has become an important issue facing the teaching field. Hegde and Bishop [7] explored effective teaching strategies to achieve this goal. It utilizes simulation software or virtual reality technology to allow students to engage in design practice in a simulated environment. Through real-time feedback, students can intuitively understand the effectiveness of their designs in meeting visual needs and adjust design plans promptly. At the same time, teachers can provide targeted guidance based on the performance of students to improve teaching effectiveness. Select representative interior design cases and organize students to have in-depth discussions and Analyses. This helps to cultivate students' critical thinking and improve their ability to apply the knowledge they have learned to solve problems in practical projects. Through collective discussion, students can learn from each other, progress together, and improve the overall quality of teaching.

With the development of technology, intelligent assisted indoor building systems have become an important component of modern architectural design. However, in practical applications, the robustness of cascaded systems is seriously challenged due to their imperfections. Hong et al. [8] explored how to perform robust design on intelligent assisted building indoor systems with imperfect cascaded CSI. A cascade system refers to a complex system composed of multiple subsystems, where the output of each subsystem serves as the input for the next level subsystem. In intelligent assisted building indoor systems, data needs to be transmitted between various subsystems. Due to network congestion, device failures, and other reasons, data transmission may experience delays or losses, affecting the real-time stability of the system. The subsystems in the indoor system of intelligent assisted buildings may experience malfunctions or abnormalities due to various reasons, which can affect the performance of the entire system. By using redundant design and fault detection and isolation technology, the reliability and stability of subsystems can be improved, and the impact of factor system failures on the entire system can be reduced. Dynamically adjust the parameters and performance of subsystems to adapt to different scenarios and requirements based on environmental changes and user needs. With the advancement of technology, evolutionary computing, as an intelligent optimization algorithm, is playing an increasingly important role in interior design. Huang et al. [9] explored the design categories, processes, and recommendations of interactive evolutionary computing in interior design experiments and conducted research based on data-driven approaches. In interior design, the application of interactive evolutionary computing mainly includes the following aspects: spatial layout optimization, lighting design, colour matching, and material selection. These categories are crucial elements in interior design, directly affecting the overall effect and user experience of the design. It utilizes visualization technology to enable designers and users to have a more intuitive understanding of the effectiveness and performance of design solutions. At the same time, it provides a friendly interactive interface to facilitate personalized customization and adjustment by users. Strengthen cooperation and communication with other related disciplines, such as architecture and psychology. Through interdisciplinary cooperation and the comprehensive application of knowledge and methods from different disciplines, the overall and comprehensive design can be improved.

With the development of 3D reconstruction technology, obtaining 3D spatial information from 2D images has become possible. However, for indoor environments, achieving accurate indoor 3D shape expansion remains a challenge due to their complex structure and dynamic properties. Liu et al. [10] proposed a new method to achieve quantitative and flexible indoor 3D shape expansion by combining latent space embedding and deformation learning. In early research, researchers mainly focused on restoring three-dimensional structures from a single two-dimensional image through various algorithms. In recent years, the application of deep learning in the field of 3D shape expansion has become increasingly widespread. Especially deep learning models such as Generative Adversarial Networks (GANs) and Variational Autoencoders (VAEs) have shown strong capabilities in dealing with such problems. However, existing methods still struggle to achieve accurate and flexible 3D shape expansion when dealing with indoor environments. Potential spatial embedding is a technique of embedding high-dimensional data into low-dimensional space, which can help us better understand and represent the intrinsic structure of data within limited data. In the expansion of indoor 3D shape measurement, we use latent space embedding to extract and represent indoor structural information. Metamorphic learning is a method of transforming and adjusting data by learning the inherent laws of data distribution. In our method, we use deformable learning to optimize and adjust the results of potential spatial embeddings, making them more in line with the real indoor environment. With the rapid development of technology, big data technology is gradually changing the way various industries operate, including the fields of architecture and design. Pei et al. [11] explored how to use RIS (Remote Intelligent Sensing) technology for on-site testing of indoor/outdoor design under the drive of big data. Big data refers to a collection of data with a large volume, diverse types, and complex processing. In architectural design, big data can help designers obtain more comprehensive information, optimize design schemes, and improve the accuracy and efficiency of decision-making. In architectural design, RIS technology can be used to obtain real-time data on construction sites, providing designers with more accurate on-site information. Using RIS technology, designers can collect real-time data on indoor/outdoor design sites, including environmental temperature, humidity, light intensity, building material characteristics, etc. These data are transmitted to the data centre through sensors for processing and Analysis, providing designers with detailed design parameters and reference information.

With the advent of the big data era, the application of 3D interior design in the field of interior design is becoming increasingly widespread. Yang [12] explores how to use 3D interior design to optimize teaching and improve students' design abilities and innovative thinking under the drive of big data. Big data can provide rich data resources and case support for 3D interior design teaching. By analyzing a large amount of actual project data, students can understand the characteristics, application scenarios, and market demands of different design styles, providing strong references for their design practices. Meanwhile, through data mining and Analysis, students can discover patterns and trends in design, stimulating their innovative thinking. Introducing 3D design software, such as SketchUp, Revit, etc., in teaching enables students to engage in 3D modelling, rendering, and interaction through the software. Through practical operations, students can have a more intuitive understanding of the spatial relationships, material properties, and lighting effects of interior design, improving their design perception ability. Strengthen cooperation and exchange with other related disciplines, such as architecture, environmental art and design, etc. Through interdisciplinary collaboration, students can comprehensively apply knowledge from different disciplines, broaden design ideas, and improve the overall and comprehensive design. In the era of big data, the speed of information flow is accelerating, and user needs are becoming increasingly diverse. Interior design, as a field closely related to people's lives, needs to constantly adapt and meet these changes. Zachos et al. [13] explored how to optimize interior design style using spatially weighted minimum network evolutionary design under the drive of big data. Firstly, big data provides rich data resources and powerful analytical capabilities for interior design. By collecting, organizing, and analyzing a large amount of interior design style data, designers can gain a deeper understanding of the characteristics, advantages and disadvantages, and application scenarios of different styles. These data not only help designers better understand user needs and market trends but also provide inspiration and guidance for designers to create designs that better meet user expectations. However, relying solely on big data is not enough. Designers also need to master advanced design methods and tools to achieve their design intentions better. Among them, spatially weighted minimum network evolutionary design is a very effective design method. This method abstracts various elements of interior design style by constructing a spatial weighted network model and uses evolutionary algorithms for optimization and iteration to find the optimal design solution.

With the rapid development of technology, the application of big data and additive manufacturing technology in the field of interior design is becoming increasingly widespread. Zhang et al. [14] explore how to use CAD (Computer Aided Design) technology and additive manufacturing technology to design and preprocess interior design style additive manufacturing under the drive of big data. Firstly, big data plays a crucial role in interior design. By collecting and analyzing a large amount of interior design data, designers can gain a deeper understanding of the characteristics, elements, and trends of various design styles. These data can provide valuable inspiration and reference for designers, helping them create more distinctive and attractive designs. Driven by big data, CAD technology has become an indispensable tool in interior design. CAD software can help designers quickly and accurately draw design drawings on a computer and conduct simulation analyses of various parameters and performance. Through CAD technology, designers can better achieve their design intentions and improve the feasibility and efficiency of their designs. Additive manufacturing technology has brought new possibilities to interior design. With the rapid development of wireless communication technology, the design of reflector-assisted channels and practical passive beamforming in intelligent buildings has become increasingly important. Zheng et al. [15] reviewed these two technologies and explored their applications and advantages in intelligent buildings. The reflective surface-assisted channel is a technology that utilizes the reflection surface of buildings to enhance the transmission quality of wireless signals. By carefully designing the shape and material of the reflection surface, wireless signals can be effectively reflected to the receiving end, improving the coverage range and transmission rate of the signal. Reflective surfaces can reduce the attenuation and interference of wireless signals during transmission and improve the signal-to-noise ratio of the signal. The reflective surface auxiliary channel is suitable for various types of intelligent buildings and can be customized according to the building structure and layout.

The above research has made remarkable contributions to the trend prediction of interior design style and CAD application and provided strong support for the innovative growth of the interior design industry. However, these studies also have some shortcomings, such as the limitation of data sources, the limited generalization ability of forecasting models, and the difficulty in covering the diversity of user needs. Because of the contributions and shortcomings of the above research, this article proposes the following improvement measures:

Expanding data sources and integrating data from multiple fields to improve the accuracy and comprehensiveness of predictions;

Optimizing the prediction model and adopting more advanced machine learning and deep learning algorithms to improve the generalization ability of the model;

Digging deeper into user needs, combining emotion computing and natural language processing technology to capture users' hidden needs more accurately;

Strengthen cross-industry cooperation, promote the collaborative growth of the interior design industry and upstream and downstream industries, and build a more complete industrial ecosystem.

3 BIG DATA-DRIVEN PREDICTION OF INTERIOR DESIGN STYLE TRENDS

With the continuous innovation of information technology, big data has gradually penetrated various industries and become an important force driving social development. In the field of interior design, the application of big data also shows broad prospects and potential, especially in predicting design style trends. This section will provide a detailed introduction to how to use big data technology to predict interior design style trends, including data sources, data processing methods, and the construction and application of prediction models.

3.1 Data Sources

To predict the trend of interior design style, it is necessary first to obtain a large amount of relevant data. These data sources are extensive, including but not limited to the following aspects:

⊖ Social media data: With the popularity of social media, more and more users are sharing their home design photos, decoration experiences, etc., online. By crawling data from these social media platforms, a large amount of user preferences and trend information about interior design styles can be obtained.

⊜ E-business platform data: There is a large amount of sales information for home products on e-business platforms, including furniture, lighting fixtures, decorations, etc. By analyzing the sales data of these products, we can understand the purchasing preferences and consumption trends of users and then infer the popular trends of interior design styles.

⊛ Design websites and forums: Professional interior design websites and forums gather a large number of designers and decoration enthusiasts, where they share their design works and discuss design concepts and trends.

④ Historical Design Cases: Historical design cases record the evolution process of interior design styles, and by analyzing these cases, we can understand the popular cycles and changing patterns of various design styles.

3.2 Construction and Application of Predictive Models

After obtaining the raw data, a series of processes is required to predict the trend of interior design style. The main steps of data processing include data cleaning, feature extraction, and data annotation. Due to the potential presence of a large amount of noise and irrelevant information in the original data, it is necessary to clean the data, remove duplicates, errors, and invalid data, and ensure the accuracy and reliability of the data. Extract features related to interior design style from the cleaned data, such as colour, material, shape, layout, etc. For the convenience of subsequent model training and assessment, it is necessary to annotate the extracted features, that is, label each feature with a corresponding style label.

Upon completing data processing, the trend of interior design style is forecasted using an ANN model. ANN is a computational framework that mimics the interconnected structure of human brain neurons. It excels in learning, representation, and tackling intricate nonlinear challenges. To begin, a multi-layered ANN model is established, comprising an input layer for receiving processed interior design style features, a hidden layer for extracting deeper data characteristics through nonlinear mappings, and an output layer for generating predicted style labels. Figure 1 illustrates the fundamental architecture of the ANN model tailored for interior design style trend predictions.

In the ANN model, it is necessary to determine the structure and parameters of the network. In terms of structure, choose the appropriate number of network layers and neurons based on the complexity of the problem and the size of the data. In terms of parameters, weights and bias terms are randomly initialized, and backpropagation algorithms are used to update and optimize weights.

Let y_t denote an observable variable in the $k\times1$ dimension, encompassing k design styles. These variables are associated with the $m\times1$ dimension represented by vector a_t . The measurement equation is formulated as follows:

$$y_t = z_t \times a_t + d_t + \mu_t \quad t = 1,2,\ldots,T \tag{1}$$

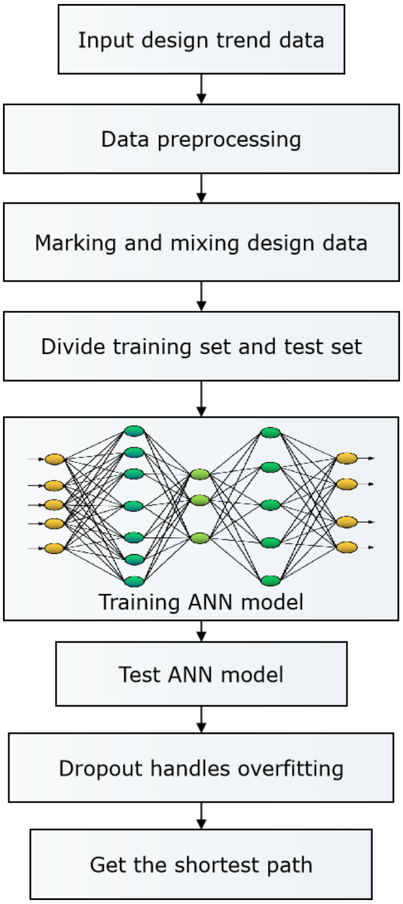

Figure 1: ANN model.

In this context, T signifies the sample length, z_t corresponds to the $k \times m$ matrix, while d_t represents the $k \times 1$ vector. μ_t On the other hand, it denotes the $k \times 1$ vector, which serves as a continuous disturbance term that is uncorrelated, with a mean value of 0 and a covariance matrix designated as H_t.

$$E \; \mu_t \; = 0, \quad \text{var} \; u_t \; = H \tag{2}$$

The elements a_t are generally unobservable, and the equation of state is defined as:

$$a_t = T_t a_{t-1} + c_t + R_t \xi_t \quad t = 1,2,\ldots,T \tag{3}$$

Where T_t stands for $m \times m$ matrix, c_t stands for $m \times 1$ vector, R_t stands for $m \times g$ matrix, ξ_t stands for the mean value of $g \times 1$ vector of 0, and the covariance is the random uncorrelated perturbation term of Q_t :

$$E\ \xi_t\ = 0, \quad \mathrm{var}\ \xi_t\ = Q_t \tag{4}$$

During the model training phase, use the annotated training dataset to train the ANN model. The standardized optimal index set is used as the reference data column, and the standardized index value $y_{i1}, y_{i2}, y_{i3}, \ldots, y_{im}$ is used as the compared data column. Then, use the following formula to calculate the grey correlation coefficient:

$$\delta_i\ j\ = \frac{\min_i \min_j \left|s_j - y_{ij}\right| + \rho \max_i \max_j \left|s_j - y_{ij}\right|}{\left|s_j - y_{ij}\right| + \rho \max_i \max_j \left|s_j - y_{ij}\right|} \tag{5}$$

In this context, $\delta_i\ j$ denotes the correlation coefficient that exists between the j index of the i sample and the optimal j index value within the set of optimal indices. ρ Represents the resolution coefficient, which is typically set to 0.5. Subsequently, the grey assessment matrix is derived.

$$E = \begin{bmatrix} \delta_1\ 1 & \delta_1\ 2 & \ldots & \delta_1\ m \\ \delta_2\ 1 & \delta_2\ 2 & \ldots & \delta_2\ m \\ \ldots & \ldots & \ldots & \ldots \\ \delta_n\ 1 & \delta_n\ 2 & \ldots & \delta_n\ m \end{bmatrix} \tag{6}$$

The degree of correlation between the comparison and reference series is indicated by the correlation degree:

$$\gamma_{0i} = \frac{1}{n}\sum_{k=1}^{n} \gamma_{0i}\ k \tag{7}$$

In this context, $\gamma_{0i}\ k$ it represents the correlation degree, which is calculated as the mean of the correlation coefficients for the identical factor.

Define a set $O = \ O_1, O_2, \ldots, O_r$ comprising r targets, and a domain $A = \ a_1, a_2, \ldots, a_n$ encompassing n schemes. Denote O_i this as the goal, and let the membership degree of the scheme within be documented $\mu_{oi}\ \alpha$. Consequently, the decision function D ought to encompass the entirety of goals.

$$D = O_1 \cap O_2 \cap \ldots \cap O_r \tag{8}$$

Hence, the membership degree about the decision function D for every individual scheme is determined as follows:

$$\mu_d\ \alpha\ = \max\left[\mu_{o1}\ \alpha\ , \mu_{o2}\ \alpha\ , \ldots, \mu_{or}\ \alpha\ \right] \tag{9}$$

The optimal interior design decision scheme, denoted, α^* will adhere to the subsequent criteria:

$$\mu_D\ \alpha^*\ = \min\ \mu_D\ \alpha\ \forall a \in A \tag{10}$$

In this context, α^* it represents the most suitable solution while A designating the collection of components where potential errors may arise.

In practical applications, the trained ANN model is deployed on an online interior design platform to provide users with real-time design style trend prediction services. Users can obtain personalized design style suggestions and recommendations by uploading their home photos or selecting their preferred design elements. This will help users better understand the current popular design styles and guide them in making decoration decisions and purchasing choices. By constructing and applying ANN models, big data-driven trend prediction of interior design styles can be achieved. This will bring many benefits to the interior design industry, including improving design efficiency, meeting user needs, and promoting innovative design.

3.3 Analysis of Prediction Results

ANN is a variable structure system whose strong self-learning ability and adaptability to the environment mainly come from its unique structure and training mechanism. During the training process, the neural connections in the network can be adjusted based on the characteristics of the input data and the training objectives, including increasing or decreasing connections or modifying weights. Due to the adjustable structure and weights of the network, when the external environment or the distribution of input data changes, the neural network can adapt to these changes through retraining. From Figure 2, it can be seen that the output data of the trained ANN can approximate the real market development data well. This indicates that the network has converged to a good state, and its internal weights and structure can accurately capture the relationship between input and output.

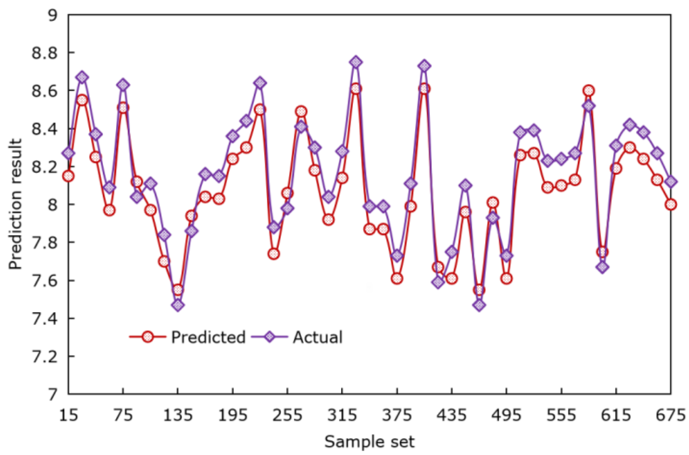

Figure 2: Machine learning results.

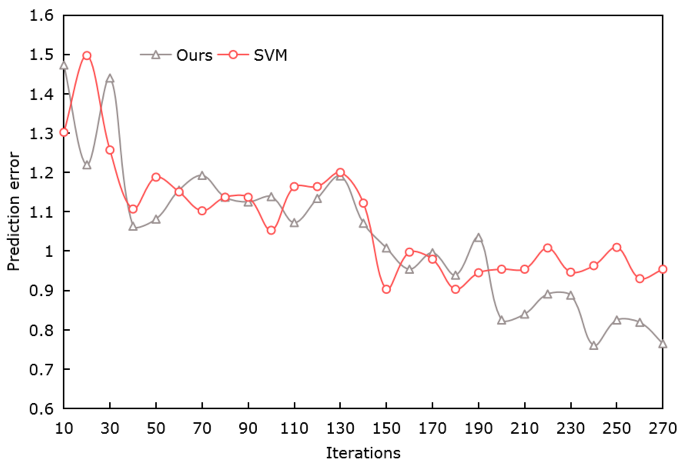

Figure 3: Comparison of algorithm MAE.

Figure 3 shows the comparison of errors generated by using different algorithms for indoor design style trend prediction at different training stages. As the training iterations increase, the prediction error of this algorithm gradually decreases and eventually tends to a relatively stable level. In contrast, traditional prediction methods exhibit higher errors, and these errors do not show a significant downward trend during the training process.

This algorithm can gradually learn complex patterns and relationships in input data through multiple iterations of training. As the training progresses, the network continuously adjusts its internal weights and structure to better fit the training data and ultimately achieve accurate prediction of unknown data. However, traditional prediction methods are usually based on fixed mathematical models or statistical assumptions, and they do not have a similar learning process, so their adaptability to data is poor.

Figure 4 shows the comparison of response speed between this method and the comparison method. Both in the initial and later stages of operation, this method has shown significant advantages, with a response speed increased by more than 15% compared to the comparison method. This result reflects the efficiency of this method in algorithm design and implementation.

Figure 4: Response speed comparison.

This method adopts a more efficient data structure and algorithm logic in algorithm design. By reducing unnecessary computational steps and memory access, this method can complete the same computational task in a shorter time, thereby improving response speed. By assigning computing tasks to multiple processing units for simultaneous execution or utilizing specific hardware features for acceleration, this method can complete calculations in a shorter time and further improve response speed. In practical applications, this ability to respond quickly is crucial for indoor design style trend prediction tasks that require real-time or near real-time processing, providing users with more timely and accurate prediction results.

4 APPLICATION OF CAD TECHNOLOGY IN INTERIOR DESIGN

CAD technology has become an indispensable tool in the field of interior design. This section will introduce the development history of CAD technology and its key role in interior design and explain how to use CAD technology to transform predicted design style trends into actual design solutions.

4.1 Development of CAD Technology and Its Role in Interior Design

Since its inception, CAD technology has undergone revolutionary changes from 2D to 3D, from simple drawing to intelligent design. Nowadays, it has become a standard tool in the interior design industry, greatly improving design efficiency, accuracy, and visualization effects.

In the process of interior design, CAD technology plays multiple roles. It provides an efficient and precise drawing tool that enables designers to quickly convert creativity into visual graphics. The rich material library and lighting effects built-in in CAD software make the design scheme more realistic, helping customers better understand the designer's intentions. CAD technology also supports easy modification and optimization of design schemes, thereby avoiding potential problems in the early stages of design.

After mastering the prediction results of interior design style trends, designers need to translate these trends into actual design solutions. Designers can use the drawing function of CAD software to create preliminary design sketches based on predicted style trends. These sketches can include room layout, furniture placement, colour and material combinations, etc. By continuously adjusting and optimizing these elements, designers can gradually build design solutions that conform to predicted trends. With the 3D modelling function of CAD software, designers can convert 2D design sketches into 3D models. This step not only makes the design scheme more intuitive and realistic but also helps identify potential design issues and make modifications. In 3D models, designers can freely adjust parameters such as perspective, lighting, and materials to achieve the best design results. By utilizing the rendering and animation capabilities of CAD software, designers can generate high-quality renderings and dynamic demonstrations, allowing clients to have a clearer understanding of the final effect of the design proposal. These renderings and animations can not only be used as tools for communication with clients but also as references for construction teams to ensure accuracy and consistency during the construction process.

4.2 Design Example Display

Figure 5 presents an interior design rendering that combines big data analysis and fully utilizes CAD software rendering technology. This set of design drawings is not only a simple depiction of indoor space but also a product of the perfect integration of modern technology and design concepts. By collecting, organizing, and analyzing massive amounts of data, designers can accurately grasp the current market trends, user preferences, and functional requirements. These data provide designers with strong decision support, making the design plan more in line with the expectations of the target users. Using CAD software, designers can transform their creativity and ideas into concrete 3D models and present realistic effects through high-quality rendering techniques. This not only helps designers better anticipate the final design effect but also makes communication with clients and construction teams more intuitive and efficient.

The combination of big data analysis and CAD software rendering has brought higher efficiency and better user experience to interior design. Designers no longer need to rely on personal experience or conduct extensive market research to understand user needs but quickly locate design directions through data-driven methods. The interior design rendering shown in Figure 5 is a perfect combination of big data analysis and CAD software rendering technology. It not only reflects the widespread application of modern technology in the field of design but also highlights the trend of mutual integration and common development between technology and design.

5 USER EXPERIENCE ASSESSMENT

5.1 Functional Feedback Analysis

Functionality is the cornerstone of interior design, which is related to the efficiency of space use and the quality of daily life of residents. Figure 6 shows that user feedback in terms of functionality is generally positive. This indicates that the design scheme effectively meets the actual needs of users, providing a reasonable spatial layout, sufficient storage space, and convenient living flow. Designers may accurately capture the user's lifestyle habits and functional demands through in-depth communication in the early stage, thereby accurately reflecting these needs in the design.

Figure 5: Interior design renderings.

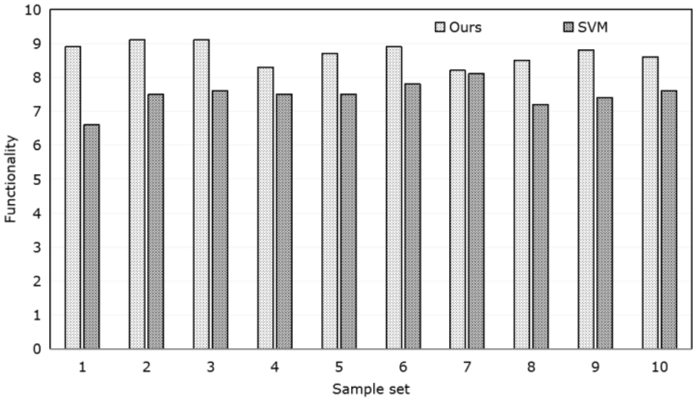

Figure 6: Functional feedback analysis.

5.2 Aesthetic Feedback Analysis

Aesthetics is the soul of interior design, reflecting the personality and taste of the occupants. Figure 7 shows that users also gave high praise in terms of aesthetics. This means that the design scheme is not only visually pleasing but also in line with the user's aesthetic preferences in terms of style, colour, and material selection. Designers may have a keen artistic perception and rich design experience, able to transform users' abstract aesthetic needs into concrete design elements, thereby creating both beautiful and personalized living spaces.

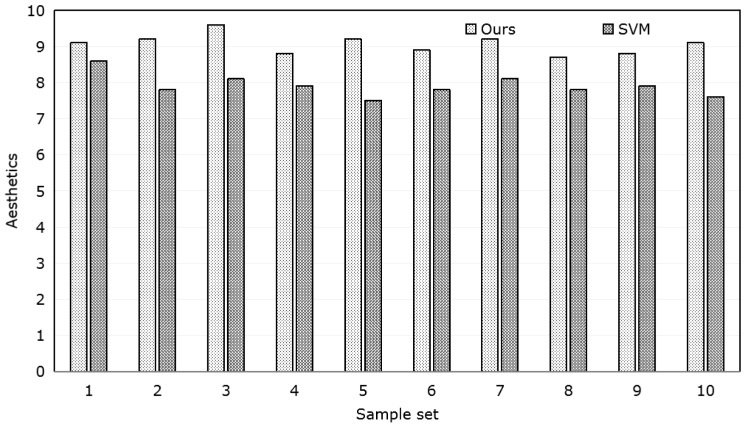

Figure 7: Aesthetic feedback analysis.

5.3 Comfort Feedback Analysis

Comfort is one of the core goals of interior design, which is related to the physical and mental health and quality of life of residents. Figure 8 shows that the user's feedback on comfort is also very positive. This indicates that the design scheme has done an excellent job in lighting, ventilation, temperature control, and furniture comfort. Designers may have applied principles of ergonomics and modern environmental psychology to create a comfortable environment that meets both human physiological needs and psychological expectations.

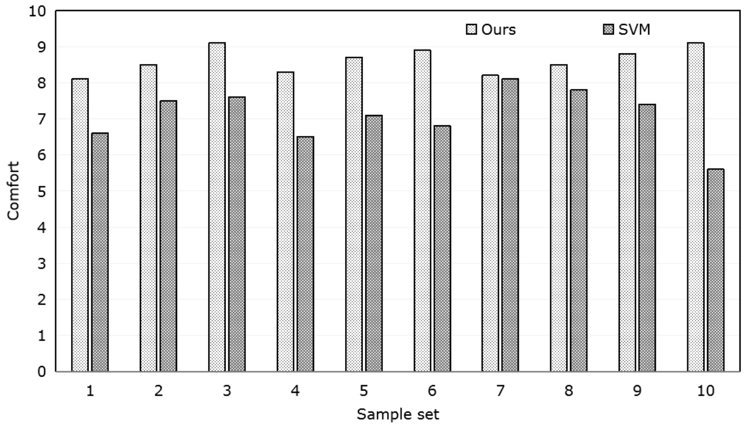

Figure 8: Comfort feedback analysis.

6 CROSS-INDUSTRY DATA INTEGRATION AND INDUSTRY CHAIN COLLABORATION

6.1 Contact and Interaction Between the Interior Design Industry and Other Related Industries

The interior design industry has close connections and interactions with multiple industries. Firstly, closely related to the construction industry, the design and construction of buildings directly affect the structure and layout of indoor spaces. Secondly, there is a close cooperation relationship with the manufacturing industry of furniture, home accessories, etc., and the design and production of these products need to be coordinated with the interior design style. In addition, interior design also integrates with industries such as art, culture, and technology, jointly promoting the growth of creativity and innovation.

By integrating data resources from industries such as architecture, home furnishings, and art, we can gain a more comprehensive understanding of market demand and consumer preferences, thereby more accurately predicting the development trends of future interior design styles. For example, by combining construction data from the construction industry and sales data from the home furnishings industry, preferences for interior design styles can be analyzed under different space types and functional requirements. Meanwhile, by utilizing big data analysis and artificial intelligence technology, deep mining and pattern recognition can be carried out on these data, further improving the timeliness of predictions.

6.2 Strategies and Suggestions for Promoting Industrial Chain Collaboration and Ecosystem Construction

In order to promote the collaboration of the interior design industry chain and the construction of the ecosystem, we propose the following strategies and suggestions:

Firstly, strengthen communication and cooperation mechanisms between industries. By establishing industry associations and regularly holding exchange meetings, we aim to promote in-depth communication and cooperation between the interior design industry and other related industries and jointly explore industry development trends and market demands.

Secondly, promote data sharing and standardization construction. Develop unified data standards and formats, promote data sharing and interoperability among various industries, and reduce the difficulty and cost of data integration.

Finally, encourages innovation and cross-border cooperation. Through policy support, financial support, and other means, encourage the interior design industry to engage in cross-border cooperation and innovative attempts with other industries and jointly develop more creative and market-competitive products and services.

7 CONCLUSION

The interior design industry is at a crossroads of change and innovation. Traditional interior design methods and processes are no longer able to meet the complex and ever-changing market demands and consumer preferences. New technologies, tools, and concepts have brought new development opportunities and unprecedented challenges to the industry. The application of big data analysis in interior design has become a trend. This article proposes a design strategy that combines big data analysis with predicting interior design style trends. Through in-depth mining of massive data, it is possible to reveal the true preferences of users, the evolution patterns of design styles, and potential market demands. By collecting, processing, and analyzing massive amounts of data, designers can more accurately grasp market trends and user needs, thereby improving the pertinence and effectiveness of their designs. Through CAD software, designers can efficiently carry out spatial planning, material selection, and rendering displays.

The growth of the interior design industry cannot be separated from policy guidance and market promotion. The government should increase its support for the interior design industry, formulate more comprehensive policies, regulations, and standards, and create a favorable external environment for the healthy growth of the industry. The market should also fully leverage its role in resource allocation and competitive incentives to promote internal transformation and upgrading within the industry.

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REFERENCES

[1] Benlian, A.; Klumpe, J.; Hinz, O.: Mitigating the intrusive effects of smart home assistants by using anthropomorphic design features: A multimethod investigation, Information Systems Journal, 30(6), 2020, 1010-1042. https://doi.org/10.1111/isj.12243

[2] Bissoli, A.; Lavino, J.-D.; Sime, M.; Encarnação, L.; Bastos, F.-T.: A human–machine interface based on eye tracking for controlling and monitoring a smart home using the Internet of things, Sensors, 19(4), 2019, 859. https://doi.org/10.3390/s19040859

[3] Ceylan, S.: A case study on the change of students' perception of architectural design based on their knowledge of digital tools, The International Journal of Design Education, 14(2), 2019, 1-16. https://doi.org/10.18848/2325-128X/CGP/v14i02/1-16

[4] Chen, J.: The role of interior design in promoting a sense of home in people with dementia living in care facilities, The Design Journal, 26(3), 2023, 483-491. https://doi.org/10.1080/14606925.2022.2144527

[5] Chen, K.-W.; Choo, T.-S.; Norford, L.-K.: Enabling algorithm-assisted architectural design exploration for computational design novices, Computer-Aided Design and Applications, 16(2), 2019, 269-288. https://doi.org/10.14733/cadaps.2019.269-288

[6] Chen, Y.-Y.; Lin, Y.-H.; Kung, C.-C.; Chung, M.-H.; Yen, I.-H.: Design and implementation of cloud analytics-assisted smart power meters considering advanced artificial intelligence as edge analytics in demand-side management for smart homes, Sensors, 19(9), 2019, 2047. https://doi.org/10.3390/s19092047

[7] Hegde, A.-L.; Bishop, N.: Simulation and reflective experience: An effective teaching strategy to sensitize interior design students to the visual needs of older adults, Art Design & Communication in Higher Education, 19(1), 2020, 33-49. https://doi.org/10.1386/adch_00012_1

[8] Hong, S.; Pan, C.; Ren, H.; Wang, K.; Chai, K.-K.; Nallanathan, A.: Robust transmission design for intelligent reflecting surface-aided secure communication systems with imperfect cascaded CSI, IEEE Transactions on Wireless Communications, 20(4), 2020, 2487-2501. https://doi.org/10.1109/TWC.2020.3042828

[9] Huang, W.; Su, X.; Wu, M.; Yang, L.: Category, process, and recommendation of design in an interactive evolutionary computation interior design experiment: a data-driven study, AI EDAM, 34(2), 2020, 233-247. https://doi.org/10.1017/S0890060420000050

[10] Liu, J.; Xia, Q.; Li, S.: Quantitative and flexible 3D shape dataset augmentation via latent space embedding and deformation learning, Computer Aided Geometric Design, 71(5), 2019, 63-76. https://doi.org/10.1016/j.cagd.2019.04.017

[11] Pei, X.; Yin, H.; Tan, L.; Cao, L.; Li, Z.; Wang, K.; Björnson, E.: RIS-aided wireless communications: Prototyping, adaptive beamforming, and indoor/outdoor field trials, IEEE

Transactions on Communications, 69(12), 2021, 8627-8640. https://doi.org/10.1109/TCOMM.2021.3116151
[12] Yang, J.: Teaching optimization of interior design based on three-dimensional computer-aided simulation, Computer-Aided Design and Applications, 18(S4), 2021, 72-83. https://doi.org/10.14733/cadaps.2021.S4.72-83
[13] Zachos, A.-N.: An evolutionary design of weighted minimum networks for four points in the three-dimensional Euclidean space, Analysis, 41(2), 2021, 79-112. https://doi.org/10.1515/anly-2020-0042
[14] Zhang, B.; Goel, A.; Ghalsasi, O.: CAD-based design and preprocessing tools for additive manufacturing, Journal of Manufacturing Systems, 52(2), 2019, 227-241. https://doi.org/10.1016/j.jmsy.2019.03.005
[15] Zheng, B.; You, C.; Mei, W.; Zhang, R.: A survey on channel estimation and practical passive beamforming design for intelligent reflecting surface aided wireless communications, IEEE Communications Surveys & Tutorials, 24(2), 2022, 1035-1071. https://doi.org/10.1109/COMST.2022.3155305