Retraction Notice

The Editor-in-Chief and the publisher have retracted this article, which was submitted as part of a guest-edited special section. An investigation uncovered evidence of systematic manipulation of the publication process, including compromised peer review. The Editor and publisher no longer have confidence in the results and conclusions of the article.

ST either did not respond directly or could not be reached.

Computer hand-painting of intelligent multimedia images in interior design major

Shufeng Tu*
College of Art and Creativity, Chifeng Industrial Vocational and Technical College, Chifeng, Inner Mongolia, China

Abstract. With the advent of the information age, the rapid development of computer software and hardware and related high-tech equipment has made today's interior design expression and display forms increasingly diversified, providing designers with a broad performance platform. On the basis of clarifying the ideas of the combined application of hand-drawn and computer graphics, we analyze the methods and approach of their combined application and expound on the actual application. It is hoped that the research can provide design ideas and references for the interior design industry and teaching activities. The Small Business Innovation Research (SBIR) program consists of three phases, the first of which is a feasibility study for the innovation. If the innovation is feasible, enter the second stage to finalize the innovative product, and after private and public sector investment, the third phase, commodity promotion and commercialization. The influence of intelligent equipment such as computers and hand-painted boards on the design industry is obvious. With the development of the social economy and the era of technological innovation, a social culture and a value system will be formed. Therefore, the arrival of media technology will also generate perceptions, ways of thinking, and value orientations and will affect our social interaction space, people's main living places, and indoor space. The software module in the computer provides designers with the opportunity to use computer design software to quickly present the designer's ideas on an electronic display screen. Its increasingly convenient design conditions promote the diversity and richness of design software. Combining intelligent multimedia images, with the help of compressed image noise reduction programming, SBIR technology, etc., it has created the development of an interior design. The number of students studying interior design has increased by nearly 60% every year, and the popularity of smart multimedia technology has also reached 78.9%. In the media age, people and interior designers are constantly changing their aesthetic tastes, narrative methods, expression methods, life function needs, and aspirations for a spiritual destination. Good interior design methods do not necessarily produce excellent interior design works, but good interior design works must be guaranteed by a set of practical design techniques and procedures. The article attempts to tap the multiple values of multimedia in indoor space to build a more humanized, humane, and media-inspired indoor space. [DOI: 10.1117/1.JEI.31.5.051418]

Keywords: intelligent multimedia image; interior design major; computer hand drawing; image processing; hand-painted expression.

Paper 220068SS received Jan. 18, 2022; accepted for publication May 3, 2022; published online May 27, 2022.

1 Introduction

This article mainly studies the new aesthetic style and the new spatial form formed after entering the indoor space with multimedia as a new technology in the context of the media age and discusses the relationship between multimedia technology and indoor space form to make an analysis. The content of digital media is becoming more abundant, the speed of information dissemination is getting faster and faster, and the era of digital revolution that brings a brand-new social vision to human life has arrived. In the era, various traditional media, including digital cinema, digital photography, digital audio, etc., have moved toward digitization, and the

*Address all correspondence to Shufeng Tu, 171843278@masu.edu.cn

1017-9909/2022/$28.00

exchange of information between media is all done by computer coding. Compared with the task of architectural design, interior design has the characteristics of faster update speed and is closer to people's daily life. Therefore, it pays more attention to the development of human society in this profession. On the other hand, interior design is closer to the spirit of modern times and keeps a keen insight into all things with modern characteristics. Interior design, as a subject with people-oriented principles, is committed to creating an indoor space environment that meets human physiological and psychological needs. The seamless connection between them has become a new topic worthy of research by designers.

At the same time, with the continuous integration of traditional civilization and modern new culture brought by multimedia, people have put forward requirements for the mediatization and intelligence of various spatial forms. In the new era and new cognition, interior space design will inevitably produce new design concepts and expressions. Intelligent multimedia image processing technology as an auxiliary tool can effectively make up for the lack of design equipment and provide users with more realistic three-dimensional images.[1] It is convenient for users to observe and analyze image data from various angles and different levels, and effectively process the data.[2] Computer hand-painting is more adaptable to the development of the market nowadays; interior design not only creates higher quality works through computer hand-painting but is also more productive. Therefore, computer hand-painting should be more convenient and quicker than traditional hand-painting, and it is more widely used in the market. Computer hand-painting satisfies people's imagination more, broadens the designer's creative ideas, and makes interior design more realistic. Quickly apply the model library, execute menu commands, and map materials so that the interior design computer renderings produced by the program often have the same appearance, gorgeous and empty, lacking spiritual thinking.

2 Related Work

At the same time, with the continuous integration of traditional civilization and modern new culture brought by multimedia, people have put forward requirements for the mediatization and intelligence of various spatial forms. In interior design, the computer's drawing function can greatly improve the efficiency of the design, and it has the advantages of accuracy, repeatability, and modification. Li and Hou[3] analyzed the architectural design and interior decoration based on VR technology and computer simulation platform. Horng et al.[4] proposed a collection system based on Internet of Things technology and intelligent image recognition. Agricultural decision-making requires a wealth of experience. Using the proposed system, a neural network model can be trained to determine the maturity of crops through target detection, and then a robotic arm can be used to harvest mature crops. Keras is used to build a multilayer perceptron machine learning model and predict the motion and position of a multiaxis robotic arm. When it comes to interior design projects, architects, owners, and suppliers rely on specialized contracts to manage the risks associated with these relationships—risks vary according to the roles of each party in the project. To support this industry sector, the American Institute of Architects is updating its series of interior design documents.[5] Wu et al.s[6] research aims to establish an architectural design knowledge transformation model to help students acquire architectural design knowledge through the learning process of socialization, extraction, externalization, integration, creation, and internalization of knowledge sharing. Wu et al.[6] started with a literature review of knowledge transfer theory and cognitive load theory to establish a knowledge transfer model of architectural design, supplemented by specially designed course content and activities. Altamimi's[7] research on technological development and the digital revolution has successfully integrated many technological applications and rolled them into more complex applications, as well as infiltrating all aspects of technology that affect buildings. Aiming at the anomaly detection problem of security early warning robots, Du[8] proposed an anomaly detection method using wireless visual sensor network (WVSN) and deep learning. First, WVSN performs image collection, and the video image information within the monitoring range is transmitted and stored by WVSN. Nam et al.[9] introduce interactive three-dimensional artworks and an algorithm for natural art expression using hand-painted images expressed by artists' manual strokes. The system puts forward a new interactive way so that the viewer can experience the painting process representing the

continuous process of the actual artist's oil painting. The combination of analog and digital technology has stimulated the mood of the audience. The system architecture consists of a Kinect sensor for recognizing user motion, module for generating real-time stereoimage and projection module for displaying the generated image. The proposed hand drawing method provides more artistic satisfaction for the audience than 3D modeling method. Life is full of digital signals, media technologies, etc. Indoor space is the main space for our life and activities. Naturally, media technology will inevitably change our living space and attitude toward life.

3 Interior Design and Display Hand-Painted

3.1 *Professional Concept of Interior Design*

After the silence of the popularity of computer graphics, people gradually realized that hand-painted representation plays an important role in the design stage, especially the material wealth value created in the program display part, but the excessive pursuit of the drawing technique of display hand-painted representation will kill the designer's style. Interior design refers to the use of material technology and architectural aesthetic principles by interior designers according to the nature of the building's use, environment, and corresponding standards to create an indoor environment with reasonable functions, comfort and beauty, and meeting people's material and spiritual life. It also needs to satisfy people's visual enjoyment, involving the integration of heat, light, sound, environment, artistic conception, and atmosphere, as shown in Fig. 1.

With the advancement of time, society's demand for interior design talents is increasing, and there is an extreme shortage of professional design talents. Count the number of applicants for other majors and design majors in recent years, as shown in Table 1.

Through the comparison of different majors, the article classifies and studies the two forms of hand-painted performance in the scheme design stage, and analyzes the application of hand-painted performance in the scheme design stage, hoping to guide design beginners quickly. From the table data, it can be seen that in the past few years, teaching majors, medical majors, and information technology majors have always been popular majors, whereas the number of applicants for interior design majors has always been relatively backward. This has also led to a shortage of interior design talents, but the employment rate of interior design professionals has

Fig. 1 The integration of heat, light, sound, environment, artistic conception, and atmosphere.

Table 1 Comparison of applicants for teaching majors, medical majors, information technology majors, and interior design majors in the past few years.

	Teaching majors	Medical majors	Information technology majors	Interior design majors
2001	200	236	185	32
2002	321	364	259	60
2003	386	414	358	150
2004	425	456	458	215
2005	521	564	521	354

Table 2 Employment rate of teaching majors, medical majors, information technology majors, and interior design majors in recent years.

	Teaching majors (%)	Medical majors (%)	Information technology majors (%)	Interior design majors (%)
2001	86.9	65.9	85.9	95.2
2002	75.2	63.2	81.5	92.9
2003	70.9	58.9	79.8	90.6
2004	65.3	45.2	78.5	86.9
2005	68.9	49.9	75.3	93.7

been the highest in recent years.[10] Statistics on the employment rates of teaching majors, medical majors, information technology majors, and interior design majors in recent years are shown in Table 2.

It is not difficult to see from the data that although the number of applicants for interior design is not so popular compared with other majors, the employment rate is indeed the highest, followed by information technology majors, teaching majors, and medical majors.[11]

But the high employment rate does not mean that the interior designer industry has no threshold. Correspondingly speaking, the professional skills that a qualified designer needs are: styling ability, drawing recognition ability, professional operation ability, and theoretical knowledge ability, as shown in Fig. 2.

How to comprehensively transmit the abilities and knowledge to be able to form three-dimensionally is to hand-paint the computer.[12]

3.2 *Demonstrative Hand Drawing*

Display hand-painting is often only regarded as a form of artistic design. Therefore, many people will ignore its practical significance and value. Demonstrative hand-painted performance is not only an art, a skill, it is also a measure of a designer's design ability.[13]

3.3 *Traditional Hand Drawing and Computer Hand Drawing*

3.3.1 *Traditional hand-painted*

Traditional hand-painted art refers to the way that designers convey design concepts through freehand or manual painting with the help of rulers, such as ancient lacquer paintings, and then

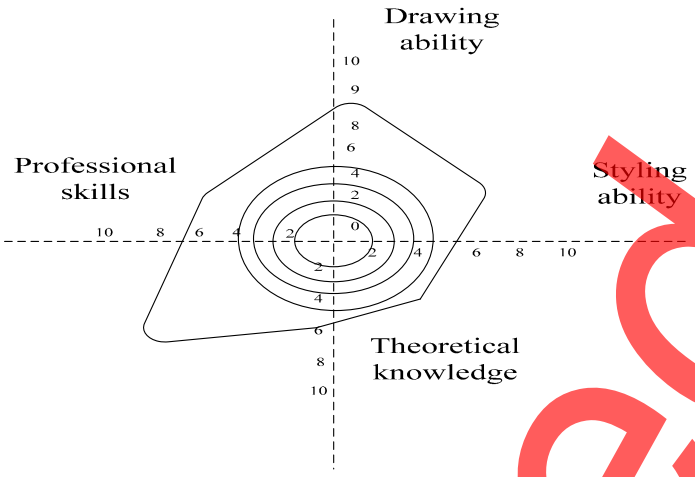

Fig. 2 Professional skills that a qualified designer needs.

Fig. 3 Traditional hand-painted.

to the Qingming picture in the Song Dynasty.[14] Therefore, modern interior design hand-drawn drawings have also made more breakthroughs in performance techniques, as shown in Fig. 3.

3.3.2 *Computer hand drawing*

The rapid development of digital media technology has created a brand-new performance platform for design expression.[15] Intelligent graphic design software such as SketchUp, Illustrator, 3Dmax, Photoshop, etc. is widely used in the design department.[16] Traditional hand-painted design is gradually replaced by computer graphic design.[17] The second is reproducibility and

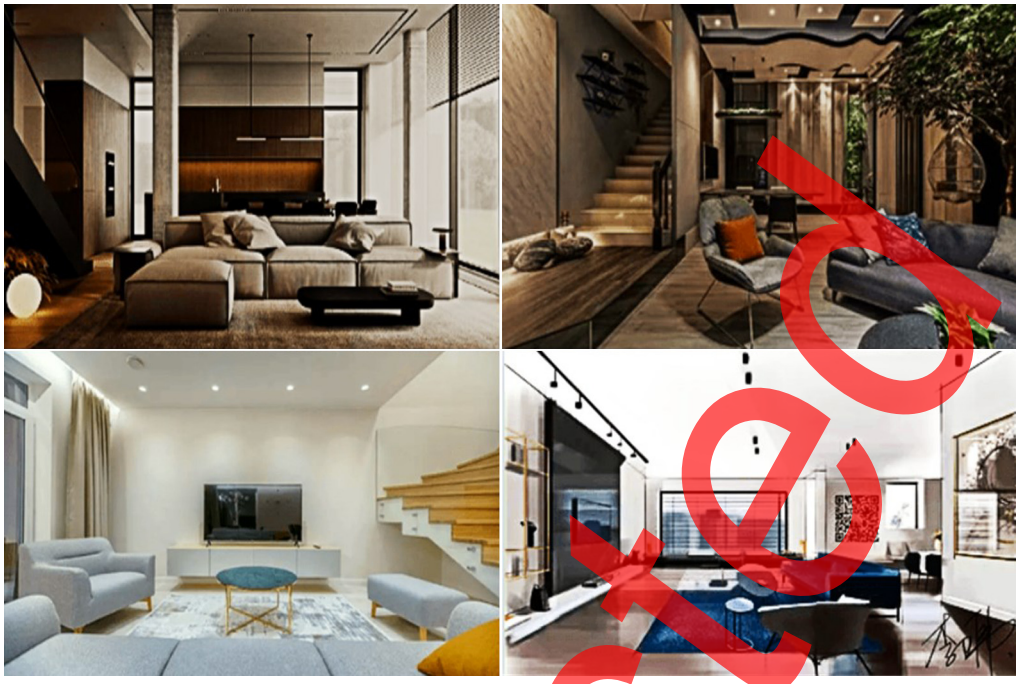

Fig. 4 Computer hand drawing.

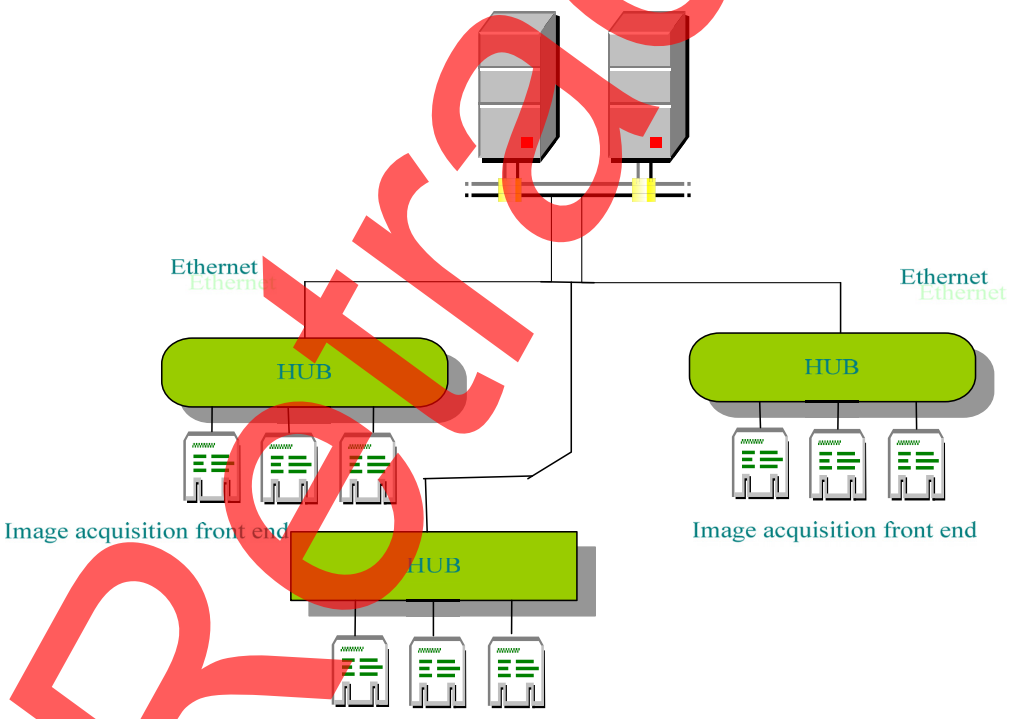

Fig. 5 System network connection block diagram.

modifiability. This feature improves work efficiency and helps improve the design. As we all know, in a set of complete design proposal bid drawings, designers often have to modify the hand drawing many times, often because of a certain part of the modification,[18] as shown in Fig. 4.

The local server is the core of the entire system, as shown in Fig. 5.

4 Smart Image Technology

With the advent of the computer age, computer graphics appear in the designer's vision, providing a brand-new display form for designers' design ideas. This form is novel, convenient, and lifelike. Today, when the development of computer graphics has begun to enter a mature stage, the most indispensable technology for computer drawing in interior design is intelligent multimedia image technology.[19]

4.1 *Compressed Image Noise Reduction Programming*

Compressed sensing is also called compressed sampling or sparse sampling. The core processing method of compressed sensing technology is that when the signal or image is sparse on a certain matrix basis, the dimensionality of the signal or image can be reduced through a measurement matrix that is not related to the sparse basis.[20]

4.1.1 *Image denoising based on filtering*

To polish the image designed for compressed sensing, remove the graininess, adjust the exposure, etc. The frequency-domain filtering process can be expressed as follows:

$$Ug(x,y) = F^{-1}[M(w,u)F(w,u)]. \tag{1}$$

If the Butterworth filter is used for processing, its transfer function can be expressed as follows:

$$M(w,u) = \frac{1}{1+[D(w,u)/D_O]^{2n}}, \tag{2}$$

$$D(w,u) = \sqrt{w^2+u^2}. \tag{3}$$

Equation (3) represents the distance from the origin of the frequency domain plane to the location (w,u).

If the Wiener filter is used for processing, its transfer function can be expressed as follows:

$$E(w,u) = \frac{|F(w,u)|^2}{|F(w,u)|^2+|N(w,u)|^2}. \tag{4}$$

When performing intelligent multimedia image denoising processing, the weighted average of the acquired images is taken, and the image edge filtering method is used at the same time. Thresholding is transformed into:

$$l(x,y) = \begin{cases} 0 & x\langle T \\ 255 & x\rangle T \end{cases}, \tag{5}$$

where T is the set threshold, and x is the pixel gray value of the point in the image. The effect of noise reduction processing on the image is evaluated at different scales, as shown in Table 3.

Refer to the evaluation results of the wavelet decomposition scale, level 4 is an ideal decomposition scale.[21]

4.1.2 *Wavelet transform*

Wavelet transform has significant advantages in analyzing and processing nonlinear signals or image information. Mallat combines the idea of multiscaling analysis with discrete wavelet transform and applies it to image processing in wireless sensor networks or the Internet of Vehicles or the Internet of Things. In recent years, the research of wavelet analysis has received great attention in the processing of intelligent images.[22]

Table 3 Image noise reduction processing to evaluate the effect at different scales.

	Level	PSNR	MSE	Time
Lena	1	28.0877	100.9974	0.7438
	2	29.6917	69.888	0.8150
	3	30.1217	0.8150	1.1094
	4	30.2008	1.2526	1.8475
IOT	1	27.5495	1.8725	2.2543
	2	29.5544	2.569	3.8712
	3	25.3321	4.0925	0.6987
	4	26.5487	0.8150	4.6541

In the wavelet transform, the assumed function

$$\eta(t) \in L^1(Y) \cap L^2(Y). \tag{6}$$

And it can satisfy

$$C\omega = \int_{-\infty}^{+\infty} \frac{|\varpi(\varepsilon)|}{|\varepsilon|} \mathrm{d}\varepsilon \langle +\infty. \tag{7}$$

After a series of translation and scaling transformations, this function can produce

$$\eta_{u,b}(t) = |a|^{\frac{1}{2}} \eta\left(\frac{t-b}{a}\right). \tag{8}$$

This formula is called a continuous wavelet, where a is the scale parameter and b is the translation parameter. Its continuous wavelet transform definition formula

$$W_f(a,b) = \langle f(t), \eta_{a,b}(t) \rangle = |a|^{-1/2} \int_{-\infty}^{+\infty} \overline{\eta}\left(\frac{t-b}{a}\right) f(t) \mathrm{d}t, \tag{9}$$

where $f(t)$ is the original signal, and the reconstruction formula of the continuous original signal $f(t)$ is

$$f(t) = C_\varphi^{-1} \int_{-\infty}^{+\infty} W_f(a,b) \varphi_{a,b}(t) \frac{dadb}{a^2}. \tag{10}$$

The wavelet decomposition of the original signal $f(t)$ is the sampled value obtained through a series of filters with discontinuous bandwidth at different scales, and the resulting graph is called a binary grid,[23] as shown in Fig. 6.

Further decomposition can be obtained

$$G(n) = (-1)^n H(2N-1-n). \tag{11}$$

In the Embedded Zerotree Wavelets coding method, a main table and an auxiliary table are constructed during specific coding. The former stores the coordinates of wavelet transform image coefficients of uncertain importance, and the latter stores the remaining values of wavelet transform image coefficients.[24] The scanning sequence of the former elements follow the following path:

$$T_0 = 2^{\wedge} \left\lfloor \log_2^{\mathrm{Max}\{|x_{w,u}|\}} \right\rfloor. \tag{12}$$

At the same time, it is necessary to determine the importance of the latter's corresponding wavelet transform image coefficients. The basic coding process steps are shown in Fig. 7.

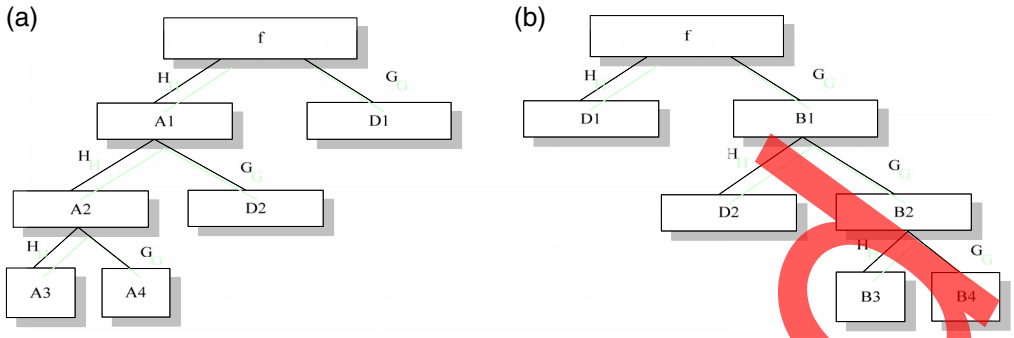

Fig. 6 (a) and (b) Binary grid of sampled values obtained through a series of filters with discontinuous bandwidth at different scales.

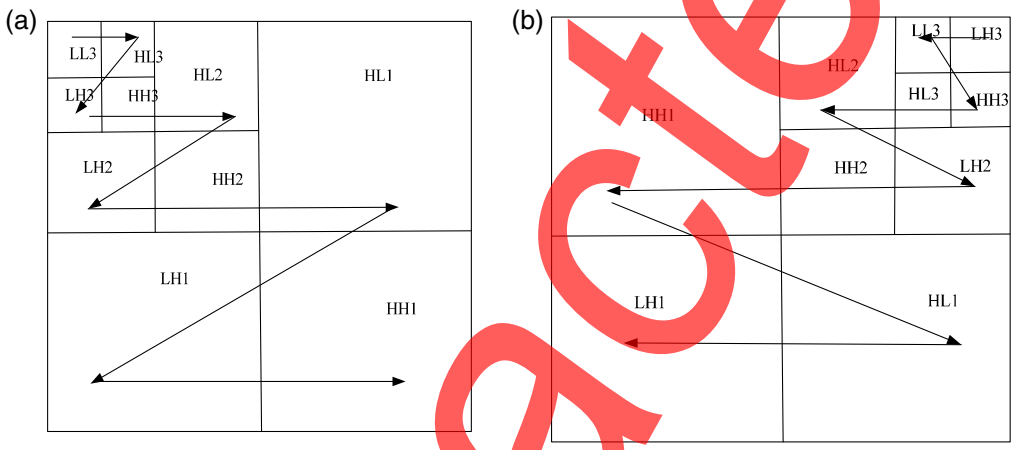

Fig. 7 (a) and (b) Basic coding process.

The decoding end also needs to construct the main table and the auxiliary table, and its function is exactly the same as that of the encoding end.[25] The former stores the coordinates of the wavelet transform image coefficients to be scanned, whereas Houze stores the decoded wavelet transform image coefficient values.

4.2 *Image Feature Extraction*

At present, FFT has been widely used in image signal feature extraction. The research found that in the FFT of an image, the phase spectrum and the amplitude spectrum often play different roles. The important characteristics of an image signal are generally contained in its phase spectrum, not in its amplitude spectrum.[26] In view of the role of the discrete fractional transform domain phase spectrum information in the feature extraction of two-dimensional digital images, the following analysis is carried out:

$$Q_l(w,u) = LL_l^{\overline{a}\,\overline{b}}(P(x,y)), \tag{13}$$

$$Q_{ll}(w,u) = L_{ll}^{\overline{a}\,\overline{b}}(P(x,y)). \tag{14}$$

The eigenvalues of the periodic fraction matrix are all taken on the unit circle.[27] Therefore, the output results of the multiparameter discrete fraction transformation are often complex-valued data. Expressing it in polar coordinate form, we can get

$$Q_l(w,u) = |Q_{ll}w,u|e^{j\varphi(w,u)}, \tag{15}$$

$$Q_{ll}(w,u) = |Q_{ll}w,u|e^{j\varphi(w,u)}. \tag{16}$$

It represents the amplitude spectrum and phase spectrum of the L-type and LL-type multiparameter discrete fractional transform, respectively, and defines them as the amplitude spectrum of the L-type and LL-type multiparameter discrete fractional transform, namely:

$$LL_{l}^{\overline{a}\,\overline{b}}(P_m(x,y)) = (Q_l(w,u)), \tag{17}$$

$$LL_{ll}^{\overline{a}\,\overline{b}}(P_m(x,y)) = (Q_{ll}(w,u)). \tag{18}$$

This is also equivalent to the exponential term of the polar coordinate expression being 1, i.e., the phase information is 0.

It is defined as the phase spectrum of L-type and LL-type multiparameter discrete fractional transform, namely:

$$LL_{l}^{\overline{a}\,\overline{b}}(P_m(x,y)) = (M_l(w,u))e^{j\varphi_l(w,u)}, \tag{19}$$

$$LL_{ll}^{\overline{a}\,\overline{b}}(P_m(x,y)) = (M_{ll}(w,u))e^{j\varphi_{ll}(w,u)}. \tag{20}$$

Among them, the unit matrix is usually taken or a generalized amplitude function. Sometimes it can also be used to represent a type of function, but it does not represent the information of a particular function.[28] Substitute and analyze the peak signal-to-noise ratio of the image after denoising under different noise intensities, as shown in Table 4.

This method has a better visual denoising effect than other related methods, and can effectively retain the detailed information of the image while denoising. Comparing the mean square error before and after the image, it can be seen that the MSE of this method is significantly lower than other similar algorithms, indicating that this algorithm has a better denoising effect. The specific data value comparison of MSE is shown in Fig. 8.

As interior design continues to develop, interior design education is changing all over the world. Since all related industries of this major originated from computer graphics. Statistics on the number of applicants for interior design majors in recent years, as shown in Fig. 9.

Table 4 Substitution analysis of the peak signal-to-noise ratio of the image after denoising under different noise intensities.

	Method	$A = 10$	$A = 15$	$A = 20$	$A = 25$
Lena	Hyperbolic shrijnkage	28.1215	26.6698	25.3651	24.6984
	Mats method	26.5478	29.6547	26.3214	25.6321
	Improved	21.6544	23.9852	28.6695	22.3654
	This paper	26.9541	25.3654	25.2145	22.5896
IOT	Hyperbolic shrijnkage	29.3654	23.6541	26.2106	26.4785
	Mats method	29.2514	65.2496	29.5874	23.2145
	Improved	27.6987	25.6547	96.3547	55.2654
	This paper	31.3256	30.5259	69.6541	26.5254

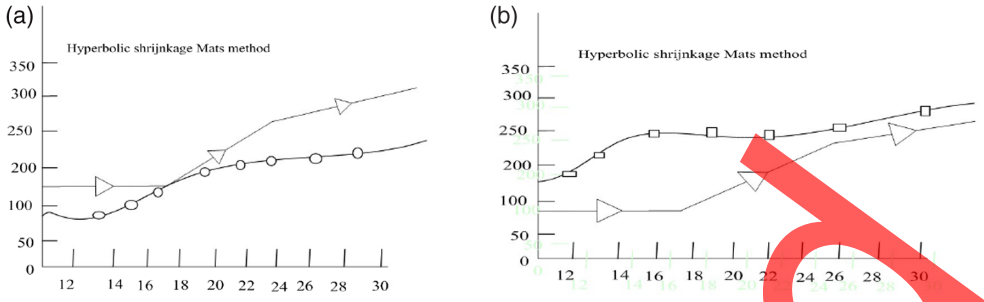

Fig. 8 (a) and (b) Comparison of specific data values of MSE.

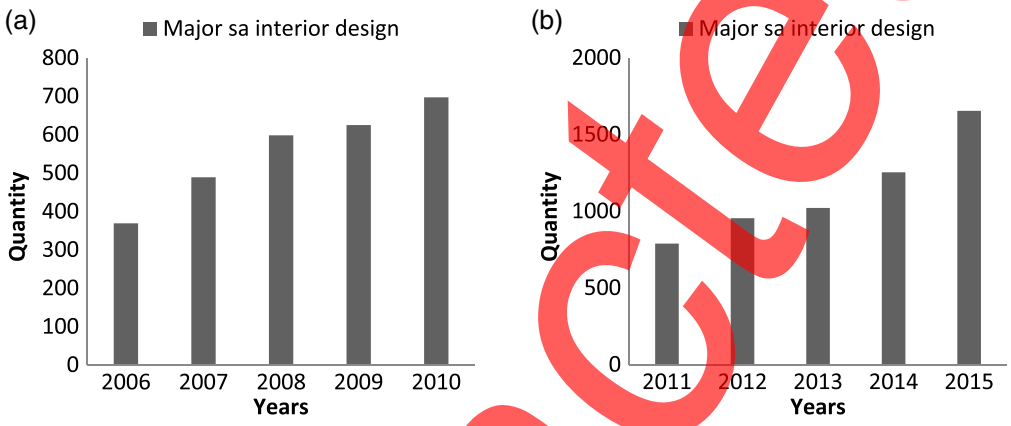

Fig. 9 (a) and (b) The number of applicants for interior design majors in recent years.

5 Simulation and Realization of Intelligent Image Processing

5.1 *Realization of Intelligent Image Processing Software*

The intelligent image flow algorithm is a magnetic automatic programming system based on image information. After further processing, the target vector recognition model is obtained. Using graphic programming technology, NC codes are generated according to processing conditions and process parameters to realize automatic programming of NC programs. The system can automatically generate numerical control codes based on raster images.

5.2 *SBIR Technology*

Small Business Innovation Research (SBIR) technology strives to build a bridge for the similarity measurement between hand-drawn images and conventional images. SBIR mainly solves the following problems: first, hand-drawn images and conventional images belong to different types of images, and the two have obvious differences in high-level visual perception. In addition, a hand-drawn image is composed of a simple line foreground and a pure background, whereas a regular image is composed of dense pixels, and the two also have very obvious differences in the representation of the underlying pixels. Second, conventional images contain rich pixel details and more interference noise (color, texture, etc.). Hand-drawn images and conventional images belong to different types of images, and the difference in image types directly leads to the robustness of traditional image descriptors such as SIFT and HOG. Some people draw more realistically, whereas some people who are not good at drawing may draw more abstractly, as shown in Fig. 10.

Gaussian blur, also called Gaussian smoothing, is used in the preprocessing stage in computer vision algorithms to enhance the image effect of images at different scales. The Gaussian blurring of the training set is used to obtain hand-drawn images of different scales to suppress the negative effects of the hand-drawn image abstraction level difference on the hand-drawn recognition work, as shown in Fig. 11.

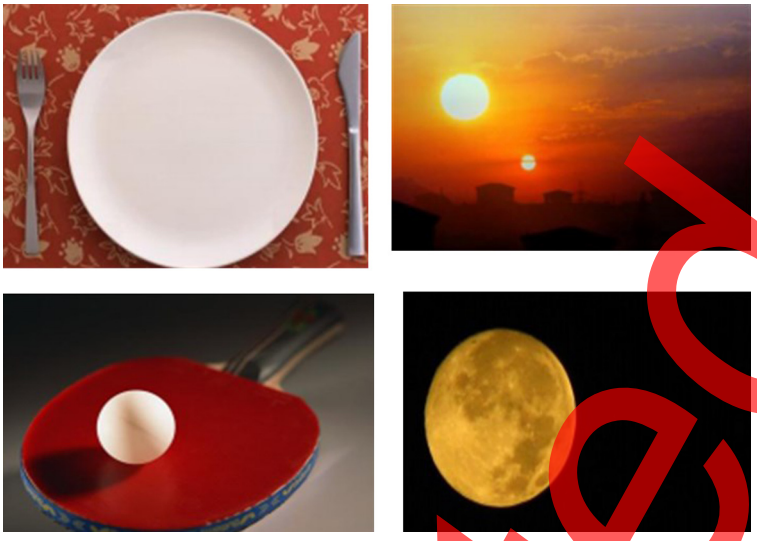

Fig. 10 For example, a circle can resemble the sun, a plate, the moon, and a ping-pong ball.

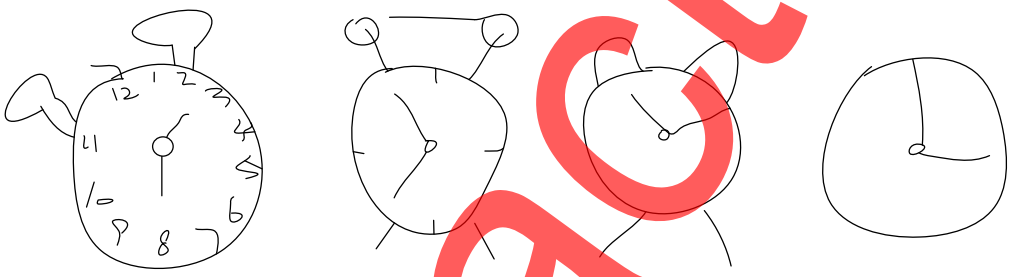

Fig. 11 Different differences in drawing an alarm clock.

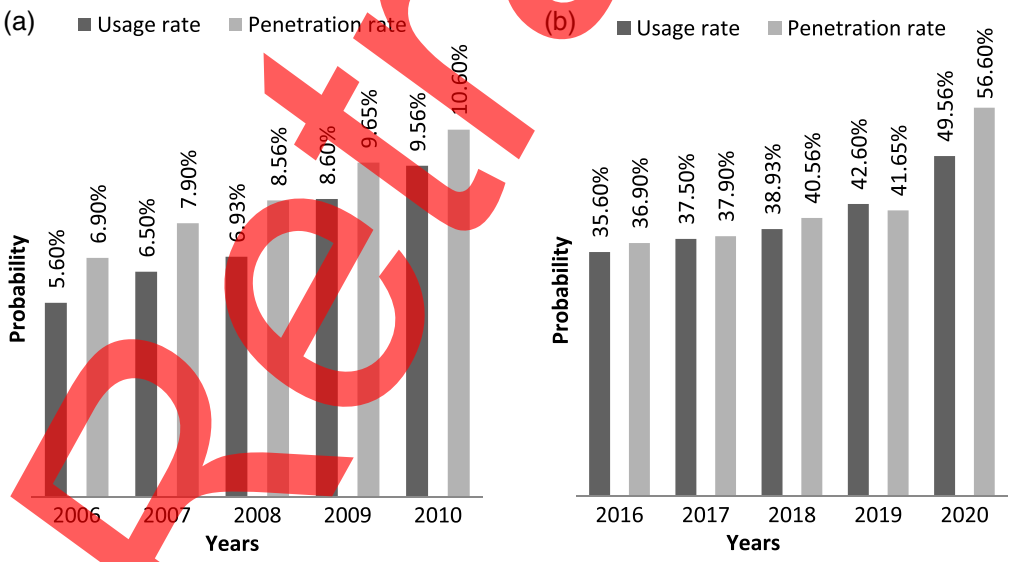

Fig. 12 (a) and (b) Utilization and penetration rate of SBIR technology in recent years.

The combination of intelligent multimedia technology and hand-painting has not only created the growth and development of the interior design profession, but the accompanying technological development has also opened the door to a new world. SBIR technology strives to establish a bridge for the similarity measurement between hand-drawn images and conventional images and has very good results in the market utilization and penetration rate. Statistics

on the utilization rate and penetration rate of SBIR technology in recent years are shown in Fig. 12.

5.3 *Hand-Drawn Dataset*

A series of evaluation experiments were conducted on the public data set Flickr15K. The Flickr15K data set contains 36 hand-drawn images and 14,660 regular images. The regular image data contains 60 categories and the hand-drawn image contains 33 categories. The conventional images in the Flick15K data set belong to outdoor images, and the proportion of natural scenery and architectural images is relatively high. Compared with conventional indoor images of regular objects, outdoor images are more affected by external conditions such as lighting, seasons, and shooting time points. In particular, images of natural landscapes have more complex expressions in terms of shape characteristics.

6 Conclusion

The digital phenomenon of intelligent multimedia images has triggered people's desire for authenticity and manual labor, and the world is rediscovering the magic of hand-drawn lines. Computer hand-painting will be more used in interior design and development. Although computer hand-painting still has its drawbacks in the application process, interior design creators can combine the advantages of traditional hand-painting and give play to the simple and convenient features of computer-based hand-painting to create more perfect works. It can be said that the development of computer hand-painting technology can promote the international development of China's interior design industry, and it can even enhance the status of China's economic industry on the world stage. The hand-painted expression of interior design is an important part of the interior design program, and the theoretical research on this needs to be further deepened.

Acknowledgments

The author declares no conflict of interest. The author received no financial support for the research, authorship, and/or publication of this article.

Ethical Approval

This paper does not contain any studies with animals performed by any of the authors. This paper does not contain any studies with human participants or animals performed by any of the authors.

References

1. H. Wei, A. Sehgal, and N. Kehtarnavaz, "A deep learning-based smartphone app for real-time detection of retinal abnormalities in fundus images," *Proc. SPIE* **10996**, 1099602 (2019).
2. G. Chen et al., "MP-RDMA: enabling RDMA with multi-path transport in datacenters," *IEEE/ACM Trans. Netw.* **27**(6), 2308–2323 (2019).
3. S. Li and Y. Hou, "Study on the architecture design and interior decoration based on VR technology and computer simulation platform," *Paper Asia* **35**(2), 54–57 (2019).
4. G.-J. Horng et al., "The smart image recognition mechanism for crop harvesting system in intelligent agriculture," *IEEE Sens. J.* **20**(5), 2766–2781 (2020).
5. M. Koger, "Updated interior design services contract documents coming soon," *Eng. News* **282**(9), 50–50 (2019).
6. Y. W. Wu et al., "A knowledge conversion model based on the cognitive load theory for architectural design education," *Eurasia J. Math. Sci. Technol. Educ.* **13**(6), 2367–2385 (2017).
7. O. Altamimi, "Augmented and virtual reality technologies in contemporary architectural design," *Emirates J. Eng. Res.* **24**(1), 4 (2019).

8. Y. Du, "An anomaly detection method using deep convolution neural network for vision image of robot," *Multimedia Tools Appl.* **79**(3), 9629–9642 (2020).
9. S. H. Nam, Y. E. Kim, and Y. M. Lim, "Materialization of interactive stereoscopic artwork based on hand-painted images," *Multimedia Tools Appl.* **77**(1), 149–163 (2018).
10. T. Hai et al., "Optimization algorithms study and implementation on graph drawing based on XML document," *Procedia Comput. Sci.* **154**, 33–39 (2019).
11. F. Kou et al., "Intelligent detail enhancement for exposure fusion," *IEEE Trans. Multimedia* **20**(2), 484–495 (2018).
12. J. S. Pan, P. W. Tsai, and H. C. Huang, "A quantization-based image watermarking scheme using vector dot product," Chapter 6 in *Advances in Intelligent Information Hiding and Multimedia Signal Processing*, J. S. Pan et al., Eds., Smart Innovation, Systems and Technologies, Vol. **63**, pp. 43–50, Springer, Cham (2017).
13. A. E. Hassanien et al., "VW16E: a robust video watermarking technique using simulated blocks," Chapter 8 in *Multimedia Forensics and Security*, A. Hassanien et al., Eds., Intelligent Systems Reference Library, Vol. **115**, pp. 161–191, Springer, Cham (2017).
14. G. Zheng, W. Tian, and X. Zhuang, "Intelligent control for human-robot cooperation in orthopedics surgery," Chapter 19 in *Intelligent Orthopaedics: Artificial intelligence and smart image-guided technology for orthopaedics*," S. Kuang et al., Eds., pp. 245–262, Springer (2018).
15. G. Khatwani and P. R. Srivastava, "Impact of information technology on information search channel selection for consumers," *J. Org. End User Comput.* **30**(3), 63–80 (2018).
16. M. Hayes, "Interior designs," *Int. Construct.* **56**(9), 49–52 (2017).
17. R. Ganesh, "Award winning acoustics in interior design," *Noise Vibration Worldwide* **48**(3–4), 41–43 (2017).
18. B. Eilouti, "Concept evolution in architectural design: an octonary framework," *Front. Archit. Res.* **7**(2), 180–196 (2018).
19. M. M. Philip et al., "Composite pattern to handle variation points in software architectural design of evolving application systems," *IET Software* **14**(2), 98–105 (2020).
20. L. Punzi et al., "The role of architectural design for rheumatic patients' wellbeing: the point of view of environmental psychology," *Reumatismo* **72**(1), 60–66 (2020).
21. E. Todella, I. M. Lami, and A. Armando, "Experimental use of strategic choice approach (SCA) by individuals as an architectural design tool," *Group Decision Negotiation* **27**(5), 811–826 (2018).
22. A. A. El-Shihy and J. M. Ezquiaga, "Architectural design concept and guidelines for floating structures for tackling sea level rise impacts on Abu-Qir," *AEJ - Alexandria Eng. J.* **58**(2), 507–518 (2019).
23. S. W. Hong, A. E. Antably, and Y. E. Kalay, "Architectural design creativity in multi-user virtual environment: a comparative analysis between remote collaboration media," *Environ. Planning B* **46**(5), 826–844 (2019).
24. B. Xia and X. Li, "Analysis and comparison on the potential of low-carbon architectural design strategies," *Sustainable Comput. Inf. Syst.* **21**, 204–211 (2019).
25. S. K. Muttoo, "An architectural design for knowledge asset management system," in *System and Architecture*, S. Muttoo, Ed., Advances in Intelligent Systems and Computing, Vol. **732**, pp. 329–338, Springer, Singapore (2018).
26. H. Seki, "Surface geometry and architectural design activities: for the ecological understanding of architectural design activities," *J. Architect. Planning* **83**(751), 1687–1694 (2018).
27. J. Dhavamani, L. H. Mujawar, and M. S. El-Shahawi, "Hand drawn paper-based optical assay plate for rapid and trace level determination of Ag+ in water," *Sens. Actuators B* **258**, 321–330 (2018).
28. M. Dougherty, "Products→trends dark green," *Hospitality Design* **40**(7), 81–83 (2018).

Shufeng Tu received his master's diploma degree from Inner Mongolia Party School. Now, he works in the School of Art and Creativity of Chifeng Industrial Vocational and Technical College. His research interests include interior design principles, residential space design, and public space design.