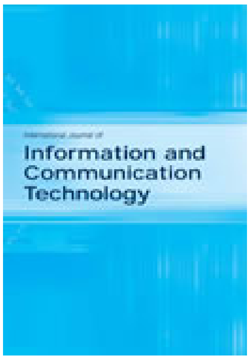


International Journal of Information and Communication Technology

ISSN online: 1741-8070 - ISSN print: 1466-6642
https://www.inderscience.com/ijict

Intelligent computer technology and its application in environmental art design

Hongyu Zhang

Article History:

Received:	25 September 2023
Last revised:	27 October 2023
Accepted:	13 November 2023
Published online:	05 March 2024

Intelligent computer technology and its application in environmental art design

Hongyu Zhang

Wuchang Institute of Technology,
Wuhan City, Hubei Province, 430065, China
Email: zhanghongyu0921@126.com

Abstract: To improve the effect of artistic environment design, this paper applies intelligent computer technology to environmental art design, and combines intelligent computer technology to provide mathematical analysis tools required for pre-computing optical energy transmission technology. Moreover, this paper discusses the diffuse and specular reflections at low frequencies, and conducts a detailed study of the rendering algorithm of the pre-computed radiance transfer (PRT) technology. In order to reconstruct the approximate function, this paper considers the opposite process of projection, and the SH function with scaled coefficients can be accumulated to approximate the original function. In addition, this paper constructs a simulation system for environmental art design. It is not difficult to see from the design evaluation results that the environmental art design system proposed in this paper can effectively improve the effect of environmental art design. This unifies the functionality of the colouring system, enabling people to handle more types of elements and flexibly utilise graphic pipelines.

Keywords: computer technology; environmental art; design; simulation.

Reference to this paper should be made as follows: Zhang, H. (2024) 'Intelligent computer technology and its application in environmental art design', *Int. J. Information and Communication Technology*, Vol. 24, No. 2, pp.213–227.

Biographical notes: Hongyu Zhang graduated from Hubei University of Art and Design and received his Master's degree in 2008. She is currently working at Wuchang Institute of Technology, where she is the Director of the Department of Digital Media Art and Environmental Art Design. Her research is digital media art design, which has won three national patents and presided over three provincial teaching and research projects. She has published three national textbooks and monographs and won the first prize in the National Teaching Design Competition.

1 Introduction

Through the commands in the computer 3D drawing software to build models, light settings, material editing, etc., in the perspective view, an accurate perspective view calculated by the computer can be obtained. Moreover, the viewing angle, material, etc. can be changed at will according to customer requirements, and the works can be observed, examined and modified from different perspectives (Zannat and Choudhury, 2019). Expanding the creative potential of designers and improving the design expression and work efficiency of designers (Bibri, 2019).

Viewers can watch space effects from different angles, giving people an immersive feeling (Mohamed et al., 2020). This kind of expression method of virtual space, which is so close to the effect of real space, is difficult to achieve by other means of expression (La Sorte et al., 2018).

As a form of visual art, it should have artistic connotation. As an important factor, the aesthetic factor of art is stored in a certain aesthetic form, that is, the art form (Gamache et al., 2018). It arouses and stimulates people's emotions through the beautiful form of art, and makes people resonate with art works (Gupta et al., 2019). All of this is built on the basis of science and technology, and is built on the fusion of computer technology and artistic connotation (Wen et al., 2020). Therefore, it can be said that science and technology influence and promote the generation and development of art in one definition; the development and achievements of art also promote and influence the progress and development of science, and the two interact and are indispensable (Manogaran and Lopez, 2017).

In order to improve the effect of environmental art design, this paper applies intelligent computer technology to environmental art design to promote the intelligent development of environmental art.

2 Related research

The use of computer graphics technology in environmental art also has negative effects. The main manifestations are: first, computer technology has brought about the 'alienation' of design, which is reflected in the specific design, which is to emphasise 'performance' over 'design'. In the process of designing a work, the time spent on design performance greatly exceeds the time spent on conception. Second, the limitations of computer technology and its software and the level of operators affect the design concept, stifle the fleeting design inspiration in the process of project conception, and make the design art creation mechanised. Third, in the teaching of environmental art design, students rely too much on computers, neglect basic skills training, pay little attention to the training of designing freehand sketches, or even give up completely, which eventually leads to the loss of design analysis, thinking, and creative ability, which greatly reduces the ability of students to design. Students' design literacy (Rao, 2018). There are many kinds of software for drawing computer architectural renderings, each of which is large in scale, has many functions, and has its own strengths, and the version is constantly updated. It is to comprehensively use their different functions according to the advantages of different software, and finally achieve the desired effect (Kang et al., 2018).

A good environmental art design rendering is not only an intuitive drawing that can accurately and clearly reflects the final effect of the expected design, but also a work of art. Ghernaout et al. (2018) believes that connotation is the spiritual factors such as the mind and thought contained in the work. The implication embodied in the design expression diagram is the expression style and inner artistic atmosphere it presents. Whether it is hand-painted performance techniques or computer graphics performance techniques, the ultimate goal is the same, that is, the artistic expression and design image. Methods and techniques are the basic elements of expression technology. No matter which expression method is used, it serves the designer. Designers should control the methods and techniques effectively in intuition and feeling, so that the designer's design ideas can be freely and flexibly passed through various aspects. A variety of performance methods and techniques are shown, not limited to a certain method and technique. Faced with the continuous improvement of the public's aesthetic taste and the mentality of seeking new and different, as a modern designer, we should have a sense of innovation. In the process of creation, designers should have the courage to try new expressive tools and methods to expand the expressive space and make expressive art an important means to adjust the relationship between visual experience and design image and the best language form for artistic interpretation of design plans (Thakur and Dharavath, 2019). Depending on the space to be expressed, the use of different expressive tools will produce very different design styles. From the perspective of visual arts, hand-painted expression techniques are more stylised and personalised, computer-aided design techniques are more homogeneous in style, and computer-aided design is more rigorous and more realistic than hand-painted expressions. After we understand the complementarity and commonalities of the two, we can take advantage of each other and avoid weaknesses in the application to give full play to their greatest advantages (Maya-Gopal and Chintala, 2020).

In the performance of environmental art renderings, according to the characteristics of the space to be expressed, we can use the combination of hand-painted techniques and computer-aided design techniques, or use the combination of various computer drawing software to create unique effects and make it more with artistic charm. But computers and brushes are tools after all, and they can only be good helpers for us to design. They are controlled by designers and cannot replace the creative thinking of design. Therefore, the key to the success of indoor and outdoor environment design renderings lies in the designer's design concept, artistic accomplishment and profound artistic skills (Lv et al., 2017).

The application of computer graphics software enables designers to design more ideal effects in a shorter period of time according to their creativity and imagination. At present, teaching institutions pay more attention to the teaching of drawing software, while ignoring the cultivation of students' aesthetic concepts and artistic accomplishment, resulting in more graduates who enter the society as 'painters' who only use computer graphics software or 'drawing tools', works lack creativity and beauty. As far as design expression drawing is concerned, it is the product of the combination of technology and art. Computer-aided design is only a means of expression. In addition to being able to master the operation methods of relevant drawing software, designers also need to have a solid artistic foundation and cultural background (Lv et al., 2017). Designers are designing living environment space for human beings, giving it certain appearance quality and characteristics, and expressing and conveying certain information, expressions or emotions through them, which are perceived by people and trigger corresponding emotions and reflections of users. The aesthetic of the design is born from this. The aesthetics of design is mainly expressed in functional beauty, formal beauty and emotional beauty. As far as interior design performance is concerned, as a designer, as a designer, it is necessary to understand whether the functional beauty is scientific, whether the layout is scientific, whether the space division is reasonable, and whether the furniture shape and size conform to ergonomics (Pencheva et al., 2020). In terms of formal beauty, it grasps various shapes and forms related to people's vision, such as the shape, colour, and pattern of interior furnishings, and then meets people's psychological needs on the basis of functional beauty and formal beauty, thereby creating emotional beauty. If students do not strengthen the study of this theoretical knowledge, they cannot achieve good performance only by means of technical means. For this reason, while attaching importance to computer graphics software, teaching institutions must not neglect the cultivation of students' aesthetic concepts and artistic accomplishment (Mavragani and Tsagarakis, 2019).

3 Research on algorithm of pre-computed light energy transfer illumination

In order to improve the design effect of environmental art, this paper combines the intelligent computer technology to give the mathematical analysis tools required by the pre-computing optical energy transmission technology. Moreover, this paper discusses the diffuse and specular reflections at low frequencies, and conducts a detailed research of the rendering algorithm of the pre-computed radiance transfer (PRT) technology.

3.1 Mathematical framework for lighting rendering of pre-computed light energy transfer

The spherical harmonic function is a normalised orthogonal basic defined on a spherical surface *S*. For spatial coordinates and normalised polar coordinates, the domain *s* is:

$$s = (x, y, z) = (\sin\theta\cos\phi, \sin\theta\sin\phi, \cos\theta) \tag{1}$$

The basic function is defined as:

$$Y_l^m(\theta, \phi) K_l^m e^{im\phi} P_l^m(\cos\theta), l \in N, -l \le m \le l \tag{2}$$

Among them, $P(l, m)$ is the associated Legendre polynomial and $K(l, m)$ is the normalised scaling factor.

$$K_l^m = \sqrt{\frac{(2l+1)(l-m)}{4\pi(l+m)}} \tag{3}$$

The above defines a complex-valued basic function. The real-valued basic functions can be obtained by a simple transformation:

$$y_l^m = \begin{cases} \sqrt{2}\operatorname{Re}\left(Y_l^m\right), m > 0 \\ \sqrt{2}\operatorname{Im}\left(Y_l^m\right), m < 0 \\ Y_l^0, \quad m = 0 \end{cases} = \begin{cases} \sqrt{2} K_l^m \cos(m\phi) P_l^m(\cos\theta), \quad m > 0 \\ \sqrt{2} K_l^m \cos(-m\phi) P_l^{-m}(\cos\theta), m < 0 \\ K_l^0 P_l^0(\cos\theta), \quad m = 0 \end{cases} \tag{4}$$

Since the SH basic functions are normalised and orthogonal, a scalar function of the *S*-domain can be projected onto its coefficients by integrating:

$$f_l^m = \int f(s) y_l^m(s) ds \tag{5}$$

In order to reconstruct the approximate function, this paper considers the opposite process of projection, and the SH function with scaled coefficients can be accumulated to approximate the original function. The approximation of low-order coefficients is often referred to as a band-limited approximation (band-limited refers to saving the part within the threshold value of the signal frequency and discarding the high-frequency part). Therefore, the reconstruction equation of the n^{th} order is:

$$\tilde{f}(s) = \sum_{l=0}^{n-1} \sum_{m=-l}^{l} f_l^m y_l^m(s) \tag{6}$$

A low-order projection of a high-frequency signal will become a band-limited signal, that is, the signal transition is very smooth.

When it is projected to order n, $n \times n$ coefficients are generated. Equation (2) is rewritten as a single index-based projection coefficient and basic function:

$$\tilde{f}(s) = \sum_{i=1}^{n^2} f_i y_i \tag{7}$$

Among them, $i = l(+1) + m + 1$. This equation makes it very convenient to reconstruct the function at s, which is to do the dot product of the $n \times n$ vectors f_i and the basic function $y_i(s)$.

$g(s) = f(Q(s))$. If Q is an arbitrary rotation about s, then

$$\tilde{g}(s) = \tilde{f}\left(Q(s)\right) \tag{8}$$

The normalised orthogonality of SH basic functions plays an important role in the fast calculation of the integral of two spherical functions.

$$\int \tilde{a}(s)\tilde{b}(s)ds = \sum_{i=1}^{n^2} a_i b_i \tag{9}$$

Convolution: This paper marks the convolution of a circular axis-symmetric kernel function $h(z)$ and a function f as $h * f$.

The projection of the convolution satisfies:

$$(h * f)_l^m = \sqrt{\frac{4\pi}{2l+1}} h_l^0 f_l^m = a_l^0 h_l^0 f_l^m \tag{10}$$

In other words, the projection coefficient of the convolution is simply the separate product of the coefficients of the two functions. $h(l, 0)$ is obtained from the analytical formula. The convolutional nature can also be used to generate pre-filtered environments utilising narrower kernels.

Product projection: The product of two spherical functions is $c(s) = a(s)b(s)$, where a is known and b is unknown, and its projection can be regarded as an urgent linear transformation of the projection coefficient b_j through matrix a.

$$\begin{aligned} c_i &= \int a(s)\left(b_j y(s)\right) y_i(s) \\ &= \left(\int a(s) y_i(s) y_i(s) ds\right) b_j = \left(a_K \int y_i(s) y_i(s) y_K(s) ds\right) b_j = a_{ij} b_j \end{aligned} \tag{11}$$

The elements of *a* can be obtained recursively using the well-known Clebsch-Gordan series by integrating the triple product of the basic functions. It is also possible to use numerical integration without pre-SH projecting the function *a*.

Here, the rotation formula (11) is:

$$R_{SH}(\alpha, \beta, \gamma) = Z_\gamma X_{-90} Z_\beta X_{+90} Z_\alpha \tag{12}$$

The following shows a rotation matrix of the third order SH coefficients rotated by an angle a around the *Z* axis.

$$Z_\alpha = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & \cos(\alpha) & 0 & \sin(\alpha) & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & -\sin(\alpha) & 0 & \cos(\alpha) & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & \cos(2\alpha) & 0 & 0 & 0 & \sin(2\alpha) \\ 0 & 0 & 0 & 0 & 0 & \cos(\alpha) & 0 & \sin(\alpha) & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & -\sin(\alpha) & 0 & \cos(\alpha) & 0 \\ 0 & 0 & 0 & 0 & -\sin(2\alpha) & 0 & 0 & 0 & \cos(2\alpha) \end{bmatrix} \tag{13}$$

For a point in the scene, considering its material and viewing direction, a general GI integral formula is:

$$L\%(n, x, \omega_0) = \int_\Omega L(x, \omega)(\cos\theta) BRDF(x, \omega, \omega_0) V(x, \omega) d\omega \tag{14}$$

For the solution of this equation, a transformation matrix to convert the incident light source to a local light source considering the occlusion term according to the projection characteristics of the spherical harmonic function, so that the orthogonal characteristics of the spherical harmonic function can be used for rendering. For current programmable GPU hardware, the constant and variable registers and the number of instructions are very limited, and the method has a considerable storage overhead even with CPCA compression.

Of course, the above formula can be simplified and approximated to make it suitable for GPU hardware accelerated applications. For most current applications, especially game development, the BRDF function term is actually not complicated, and the anisotropic BRDF is not widely used, so a BRDF function term based on spherical axisymmetric can be used for a simplification.

In most cases, the traditional Phong lighting model can be used to replace the BRDF function term, so the integral formula becomes:

$$\int_\Omega L(\omega) V(x, \omega) \times \left(A \times (n\omega) + B \times (n\omega)^{shiness} \right) d\omega \tag{15}$$

If the ambient light source is assumed to be at infinity, the *L* function does not depend on a particular position *x*. It is very difficult to integrate a function term with an exponential factor, and an analogue power function approximated by a linear combination can be adopted. Although the final result will blur the specular highlights, it greatly simplifies the calculation and improves the calculation efficiency. After the constant term is proposed, the result is as follows:

$$L\%(n, x, \omega_0) = diffuse \times \int_\Omega L(\omega)V(x, \omega) \times (n\omega)d\omega + gloss \times \int_\Omega L(\omega)V(x, \omega)(r\omega)d\omega \quad (16)$$

The $diffuse \times \int_\Omega L(\omega)V(x, \omega) \times (n\omega)d\omega$ represents the diffuse illumination contribution, denoted by $L1(x, n, 0)$, $\int_\Omega L(\omega)V(x, \omega)(r\omega)d\omega$ represents the specular illumination contribution, denoted by $L2(x, n, o)$.

$$\tilde{L}(n, x, \omega_0) = L1(x, n, \omega) + L2(x, n, \omega) \quad (17)$$

A 'bump-mapped radiosity' method is proposed, in which a set of spatially orthogonal and normalised basic vectors is used, namely:

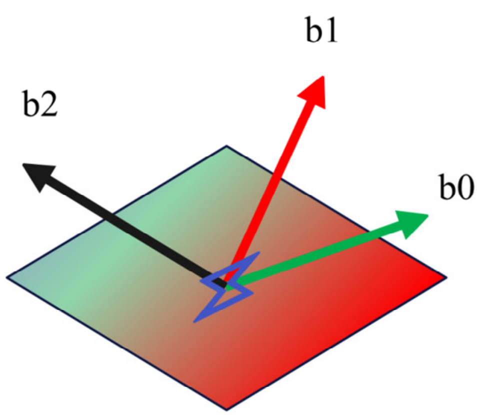
$$b0 = \left\{ \sqrt{\frac{2}{3}}, 0, \sqrt{\frac{1}{3}} \right\}$$

$$b1 = \left\{ -\frac{1}{\sqrt{6}}, -\frac{1}{\sqrt{2}}, \frac{1}{\sqrt{3}} \right\}$$

$$b2 = \left\{ -\frac{1}{\sqrt{6}}, \frac{1}{\sqrt{2}}, \frac{1}{\sqrt{3}} \right\}$$

It is abbreviated as HL2 basic vector, $b0$, $b1$, $b2$ are the three axes of the basic vector, as shown in Figure 1.

Figure 1 Half-life 2 basic vector (see online version for colours)



In order to apply global illumination effects to the GPU, taking into account that the normal of each pixel is only known at render time by looking up the normal map in the pixel shader. This may cause the GPU's pixel shader to run out of constant registers. Moreover, the amount of calculation is large, so this method is not considered. The HL2 vector decomposition method proposed in this paper can be solved with a small amount of storage and is more flexible. The details are as follows.

This paper avoids the need for the SH matrix and the CPCA compression algorithm, and uses the HalfLife 2 basic vector mentioned to decompose the normal and observation vectors of each point for the emission vector of the normal:

$$\begin{aligned} w &= w_1 \times n_1 + w_2 \times n_2 + w_3 \times n_3 \\ r &= r_1 \times n_1 + r_2 \times n_2 + r_3 \times n_3 \end{aligned} \tag{18}$$

Finally, substituting equation (18) into equation (17), we get:

$$\begin{aligned} L_1(n, x) &= w_1 \times L_1(n, \omega_1) + w_2 \times L_2(n, \omega_2) + w_3 \times L_3(n, \omega_3) \\ L_2(n, x) &= r_1 \times L_1(n, \omega_1) + r_2 \times L_2(n, \omega_2) + r_3 \times L_3(n, \omega_3) \end{aligned} \tag{19}$$

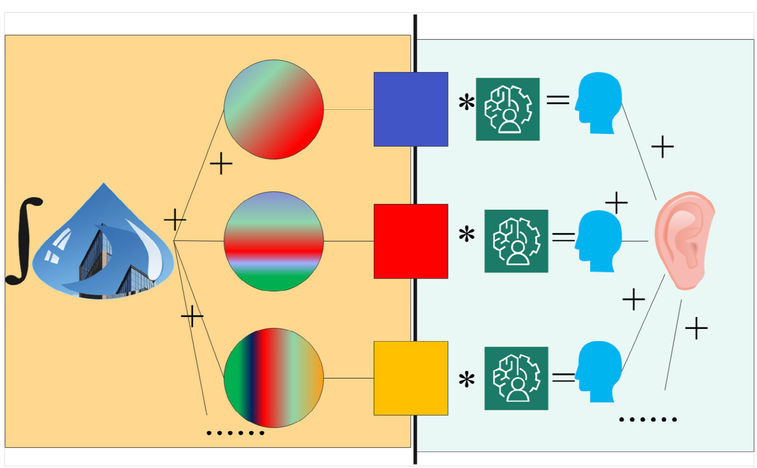
Since n_1, n_2, n_3 are all fixed, the illumination terms of the three axes in formula (16) and formula (17) can be obtained during pre-calculation. Then, calculate each weight w_1, w_2, w_3 and r_1, r_2, r_3 during real-time rendering, and the last calculation of the weighted sum can get the final lighting result, and the rendering is very flexible. In the following text, the conclusions derived and calculated here will be cited.

3.2 Light rendering of precomputed light energy transmission for low frequency environments

The integral formula for diffuse reflection from ambient light is:

$$\int_{\Omega} L(\omega) V(x, \omega)(\omega n) d\omega \tag{20}$$

Figure 2 Calculation method of diffuse reflection surface illumination for low-frequency light source (see online version for colours)

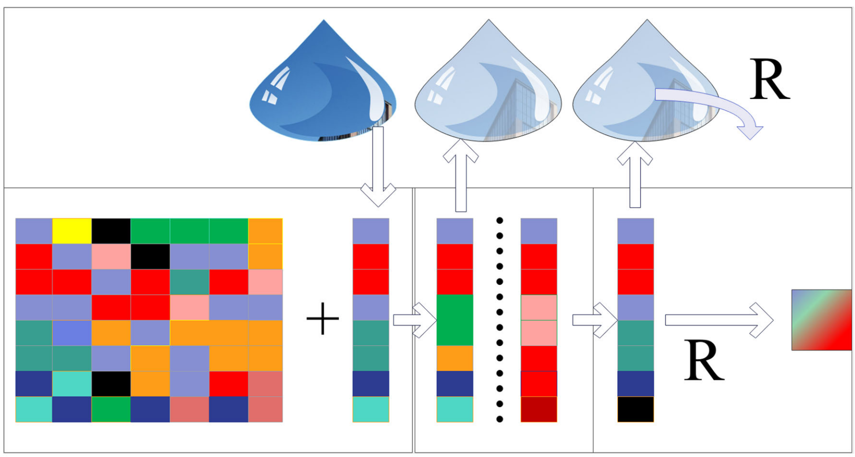


Note: The left part represents the projection coefficient of the light source environment, and the right part represents the dot product of the precomputed visibility projection factor and the left factor.

It can simulate ambient lighting very well. Afterwards, projected $L(x, \omega)$ and $V(x, \omega)$ onto the spherical harmonic function family separately, saved a set of coefficients for each vertex, and then dot-producted this set of coefficients at runtime to get the global illumination contribution at that point. The principle is shown in Figure 2. This method has been used in some well-known commercial graphics engines.

At runtime, the light source coefficient vector (length m) is multiplied by this matrix, and the distant ambient light source is converted into the local incident light source coefficient for the vertex, which already contains the occlusion information of the scene. The transformed coefficient vector is convolved with the BRDF kernel term to obtain the colouring of this vertex according to the current observation point. Its principle is shown in Figure 3.

Figure 3 Specular light calculation method in low frequency environment (see online version for colours)



Note: The left part shows that the ambient light coefficient is multiplied by the transformation matrix, the middle part shows the convolution of the converted local incident light coefficient and the core BRDF, and the right part shows that the current observation point position is substituted into the convolution result to obtain the final light colour.

However, if we consider a calculation method for simulating a light source with 16 spherical harmonic coefficients, each vertex needs to store a matrix of size 16×16, which is huge and unbearable for a high-precision model.

3.3 *Intelligent computer technology and its application in environmental art design*

From the perspective of overall unity, this paper re-plans and organises the relationship between various regions of the environment, optimises the functional complexity, and improves the utilisation rate of environmental resources (as shown in Figure 4). This paper comprehensively coordinates the various regional units in the planning and construction of the campus system, screens and categorises them according to the same or similar unit functions, and builds composite functions that form major areas (as shown in Figure 5).

Figure 4 Group analysis and composition of environmental functional areas (see online version for colours)

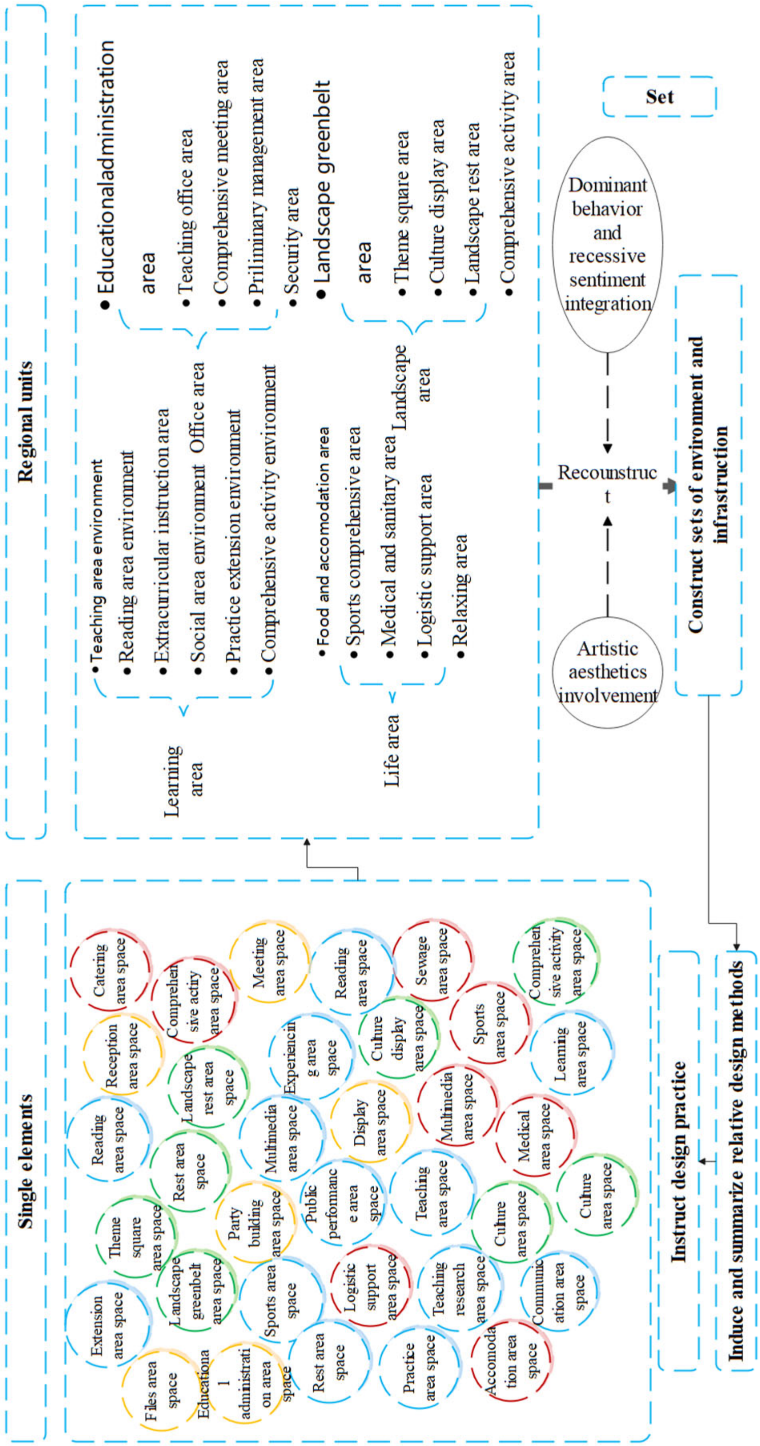
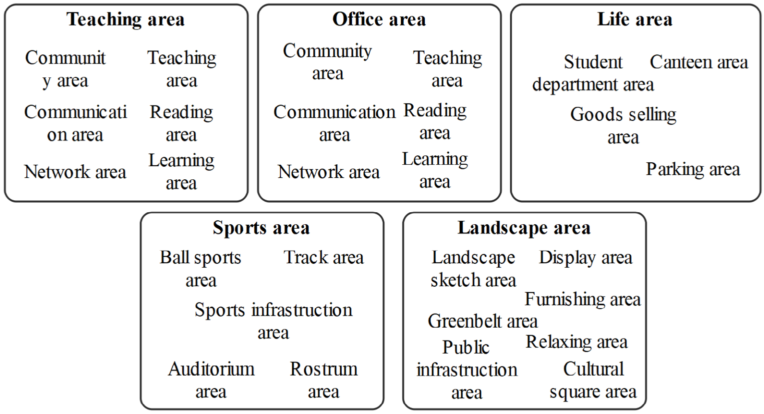


Figure 5 Statistical table of functional group classification of environmental art design system



4 Analysis and discussion

Through the induction and integration of the relevance and functionality of each region, the basic macro-level regional division is completed. On this basis, based on the design method of group structure and reorganisation, the integrity, relevance and expansion of each regional environment are constructed. The group construction process is: single module unit → regional module unit → group module unit (as shown in Figure 6). At the same time, a composite construction is carried out for the single function of each area of the campus environment. The single functional elements scattered in the area are screened for identity and similarity → the same element set is combined into a regional group → the group is systematically constructed into a group (as shown in Figure 7).

Figure 6 The deduction process of the regional group structure and reorganisation of environmental art design (see online version for colours)

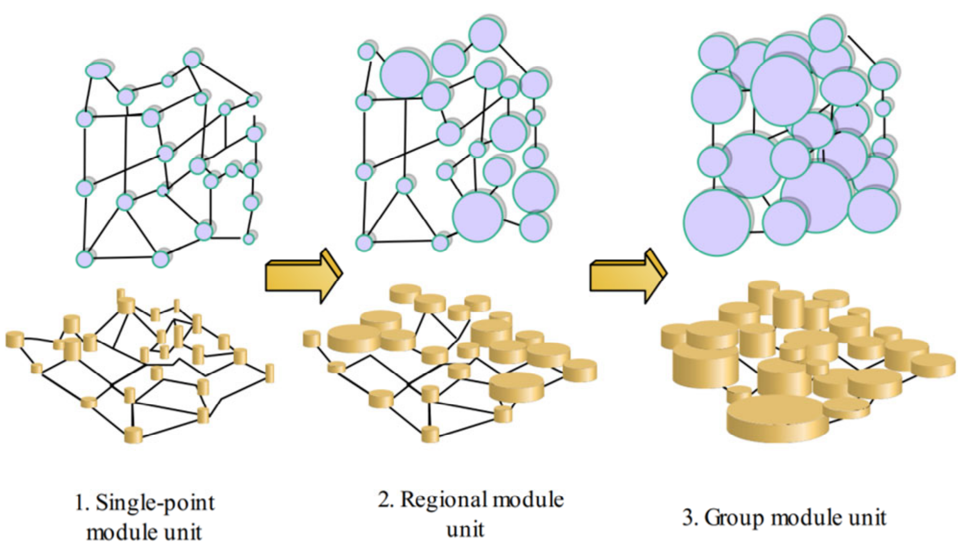
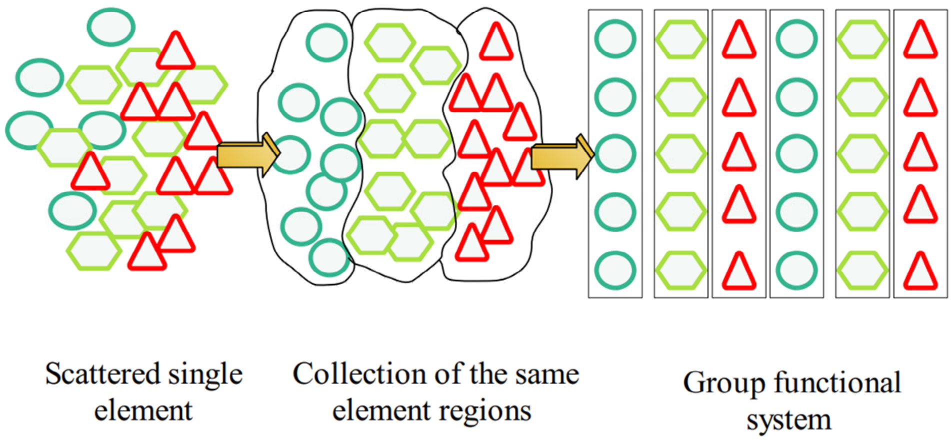
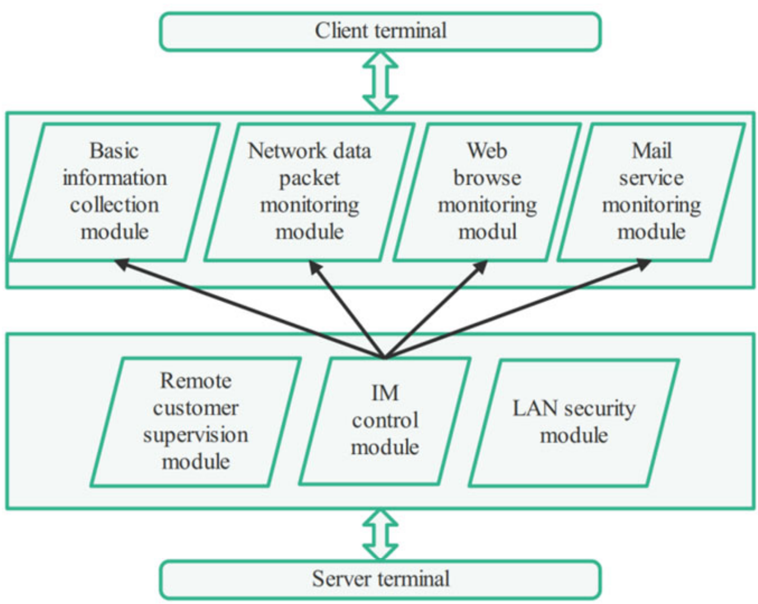


Figure 7 The process of group structure and reorganisation of environmental art design functions (see online version for colours)



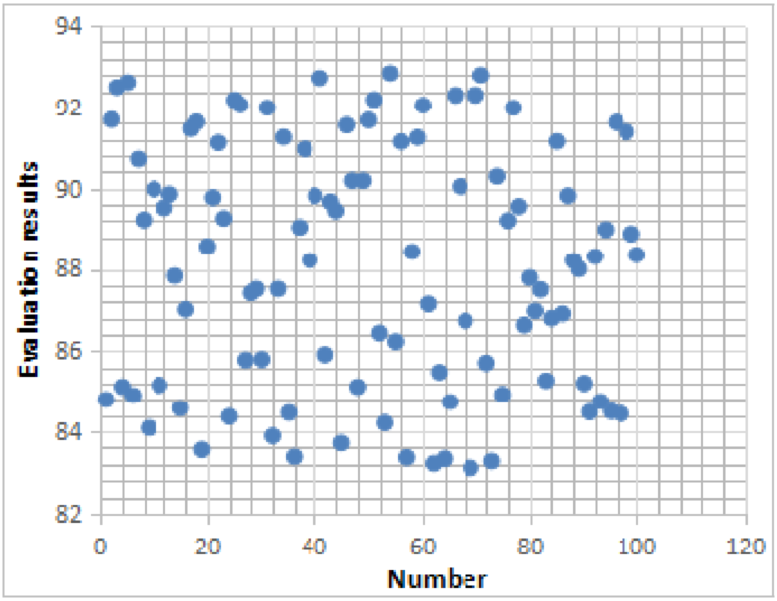
The environmental detection system mainly includes two major structures and seven modules. The organisational structure of the seven modules of these two major structures is shown in Figure 8.

Figure 8 System module architecture (see online version for colours)



After the above models are obtained, the effect of these models is verified, and the effect of the environmental art design model in this paper is evaluated by means of simulation design. The evaluation results are shown in Figure 9.

Figure 9 Evaluation of the effect of environmental art design system based on intelligent computer technology (see online version for colours)



It is not difficult to see from the evaluation results that the environmental art design system proposed in this paper can effectively improve the effect of environmental art design.

With the development of science and technology, the field of environmental art design urgently needs a new method of scheme display and discussion to make up for the shortcomings of traditional design scheme display methods, in order to more intuitively and accurately display its design intent and results to users. Applying VR technology to the display of environmental art design schemes can showcase the natural landscapes that exist in reality or the landscapes that will be constructed, or a combination of the two can be used to construct a three-dimensional model in a computer, and then use virtual reality technology to simulate the real-time visual environment. Through real-time computing on high-performance computers, real-time interactive roaming can be achieved from different perspectives and in different behaviour modes (driving, walking, flying, etc.).

Integrating VR technology into the display of environmental art design solutions, utilising computers to generate realistic virtual three-dimensional environments, and utilising appropriate display devices to mobilise users' visual, auditory, olfactory, tactile, and other senses, enabling them to experience and interact in the virtual environment space, obtaining an immersive feeling; at the same time, visitors can also directly participate in various dynamic changes of the plan, changing their emotions based on the situation and scenery, and deeply understand the concept, ideas, and content of the plan.

Integrating intelligent computer technology into the display of environmental art and design schemes can describe various parts of the spatial scheme in real-time, achieve a human-machine interactive operating environment, and change the dull and passive state between users and traditional scheme display methods. The environmental art design solution that integrates intelligent computer technology realises and emphasises the role of 'people-oriented', transforming digital information into multi-dimensional information that people can feel and deeply understand in the thinking process.

5 Conclusions

This paper applies intelligent computer technology to environmental art design, and combines intelligent computer technology to provide mathematical analysis tools required for pre-computing optical energy transmission technology. Moreover, this paper discusses the diffuse and specular reflections at low frequencies, and conducts a detailed study of the rendering algorithm of the PRT technology. In order to reconstruct the approximate function, this paper considers the opposite process of projection, and the SH function with scaled coefficients can be accumulated to approximate the original function. In addition, this paper constructs a simulation system for environmental art design. In order to improve the effect of artistic environment design, this paper applies intelligent computer technology to environmental art design to promote the intelligent development of environmental art. It is not difficult to see from the design evaluation results that the environmental art design system proposed in this paper can effectively improve the effect of environmental art design.

The research of this article applies intelligent computer vision technology to environmental art design, and verifies the effectiveness of the method from a theoretical research perspective. There is a lack of support from multiple practical cases, and it is also necessary to ensure the intelligent learning effect of the method in this article and promote continuous improvement in technology. This is also the direction of future research

Acknowledgements

This work was supported by: 2021 Scientific Planning Project of Hubei Provincial Department of Education undergrant (No. B2021327).

References

Bibri, S.E. (2019) 'On the sustainability of smart and smarter cities in the era of big data: an interdisciplinary and transdisciplinary literature review', *Journal of Big Data*, Vol. 6, No. 1, pp.1–64.

Gamache, R., Kharrazi, H. and Weiner, J.P. (2018) 'Public and population health informatics: the bridging of big data to benefit communities', *Yearbook of Medical Informatics*, Vol. 27, No. 1, pp.199–206.

Ghernaout, D., Aichouni, M. and Alghamdi, A. (2018) 'Applying big data in water treatment industry: a new era of advance', *International Journal of Advanced and Applied Sciences*, Vol. 5, No. 3, pp.89–97.

Gupta, S., Altay, N. and Luo, Z. (2019) 'Big data in humanitarian supply chain management: a review and further research directions', *Annals of Operations Research*, Vol. 283, No. 1, pp.1153–1173.

Kang, G.K., Gao, J.Z., Chiao, S., Lu, S. and Xie, G. (2018) 'Air quality prediction: big data and machine learning approaches', *International Journal of Environmental Science and Development*, Vol. 9, No. 1, pp.8–16.

La Sorte, F.A., Lepczyk, C.A., Burnett, J.L., Hurlbert, A.H., Tingley, M.W. and Zuckerberg, B. (2018) 'Opportunities and challenges for big data ornithology', *The Condor: Ornithological Applications*, Vol. 120, No. 2, pp.414–426.

Lv, Z., Song, H., Basanta-Val, P., Steed, A. and Jo, M. (2017) 'Next-generation big data analytics: state of the art, challenges, and future research topics', *IEEE Transactions on Industrial Informatics*, Vol. 13, No. 4, pp.1891–1899.

Manogaran, G. and Lopez, D. (2017) 'A survey of big data architectures and machine learning algorithms in healthcare', *International Journal of Biomedical Engineering and Technology*, Vol. 25, Nos. 2–4, pp.182–211.

Mavragani, A. and Tsagarakis, K.P. (2019) 'Predicting referendum results in the big data era', *Journal of Big Data*, Vol. 6, No. 1, pp.1–20.

Maya-Gopal, P.S. and Chintala, B.R. (2020) 'Big data challenges and opportunities in agriculture', *International Journal of Agricultural and Environmental Information Systems*, Vol. 11, No. 1, pp.48–66.

Mohamed, A., Najafabadi, M.K., Wah, Y.B., Zaman, E.A.K. and Maskat, R. (2020) 'The state of the art and taxonomy of big data analytics: view from new big data framework', *Artificial Intelligence Review*, Vol. 53, No. 2, pp.989–1037.

Pencheva, I., Esteve, M. and Mikhaylov, S.J. (2020) 'Big data and AI – a transformational shift for government: so, what next for research?', *Public Policy and Administration*, Vol. 35, No. 1, pp.24–44.

Rao, N.H. (2018) 'Big data and climate smart agriculture-status and implications for agricultural research and innovation in India', *Proceedings of the Indian National Science Academy*, Vol. 84, No. 3, pp.625–640.

Thakur, S. and Dharavath, R. (2019) 'Artificial neural network based prediction of malaria abundances using big data: a knowledge capturing approach', *Clinical Epidemiology and Global Health*, Vol. 7, No. 1, pp.121–126.

Wen, J., Yang, J., Jiang, B., Song, H. and Wang, H. (2020) 'Big data driven marine environment information forecasting: a time series prediction network', *IEEE Transactions on Fuzzy Systems*, Vol. 29, No. 1, pp.4–18.

Zannat, K.E. and Choudhury, C.F. (2019) 'Emerging big data sources for public transport planning: a systematic review on current state of art and future research directions', *Journal of the Indian Institute of Science*, Vol. 99, No. 4, pp.601–619.