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Architectures Utilizing Virtual Reality Technology in New Media Art

Kangkang Zhang[1] and Jun Fan[2*]

[1,2]School of Art, Anhui Jianzhu University, Anhui Hefei, 230601, China
[1]098010@anjzu.edu.cn,[2]keirn.fan@163.com

Corresponding author: Jun Fan, keirn.fan@163.com

Abstract. Technology in the new media environment is constantly expanding, and scientific network technology is being used in a large number of ways in life. In a new media environment, three-dimensional virtual space and human-computer interaction break the communication state in virtual reality technology. It also allows users to experience brought, but from the virtual environment, art is more realistic, giving users a realistic experience. The paper takes the red architectural heritage of a district in Shanghai as the research object, and constructs a digital archiving and virtual visualization model of the red architectural heritage of a district in Shanghai, with a simulation degree of 98.3% or more, and uses virtual technology to display and disseminate, protect and restore, serve and manage red architectural heritage, enhance people's awareness of the protection of red architectural heritage, and further promote spirit of red culture.

Keywords: VR; virtual technology; new media; art; Architecture.
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1 INTRODUCTION

Science and technology and traditional art are gradually developing and growing under the trend of times. In the field of art, new media art is an emerging art form, in line with the pace of development of times, but compared with traditional art, it has a difference: original single painting art, under the influence of new media, has emerged in many different forms, from static expression to dynamic art display, from the passive appreciation of aesthetics to main acceptance of artistic beauty [17]. In the context of new media, virtual and interactive art has emerged [14]. The background of this paper is the rapid development of computers and the consequent impact of virtual technology, which has given each field room to rise, and therefore the development of virtual roaming technology combined with art, accompanied by the impact of artistic images and convenience of function [6].

In recent years, with the rapid development of computer hardware and software technology and people's gradual awareness of its role, virtual technology has been used in many fields, which reflects the broad application prospect of virtual technology [9]. For example, virtual city [22], virtual battlefield [26], and even "Digital Earth"; These are realized through virtual technology. Based on the use of virtual reality technology, many traditional industries and industries have undergone great changes. For example, in the display product area, it is a research hotspot in this field to change the traditional display mode by using virtual technology, so as to stimulate consumption and create higher economic benefits and value.

Virtual reality is a kind of virtual scene. Based on multimedia technology, this virtual scene can simulate the real environment and use human-computer interaction to make people feel realistic [2]. Through virtual reality technology, people can interact with virtual scenes, and form sensory feedback similar to that in the real world [16]. Virtual reality technology integrates many disciplines in different fields, such as human factors engineering, network technology, pattern recognition, image processing, computer graphics, cognitive psychology, speech processing, etc. [2]. Virtual reality technology, with the help of electricity, sound, microelectronics, light, machinery and other media, forms a digital virtual space-time close to reality, so as to give people a real and illusory feeling [18].

2 RELATED WORK

In 1990s, virtual reality technology has been introduced to China, and with unremitting efforts of researchers, excellent research results have been achieved. [27] Through virtual reality technology, we have successfully simulated movement of human facial muscles and various expression changes, and have been studying body language and other detailed dynamics of human speech, and can simulate human voice, intonation and other synchronization techniques [23]. Although scholars in major literature and cases study more technology because it is recognized worldwide, art also gradually emerges from these technical aspects, and what later people study is more artistry shown by products of their predecessors. In China, compared with Europe and United States, VR research is relatively late, and there is a certain distance in level of technical development compared with other developed countries [25]. However, trend of times has led speed of technology development, and Chinese government departments and researchers of related technologies have developed research plans [20]. [12] explains some hardware basis of virtual reality technology and includes a series of auxiliary tools, such as trackers, gloves, clothes, etc. [11] lists some excellent interactive media artworks at home and abroad. And profoundly discusses study of interaction between human and machine.[13] Through display of artworks, we understand nature of interactive art and discuss how to form an immersive experience by analyzing interactive art.

Through form of computer performance, a virtual form of everything people can see into an inherent form of display [3], United States of virtual technology is almost current international level of roaming technology [10]. [21] The first attempt to simulate physical reality was to create a flight model simulator, and it succeeded in realizing people's desire to fly. [7] The development of a motorcycle simulator and realization of real feeling of roaming Manhattan, it is representative. [15] Developed a head-mounted display that can display 3D computer images and track movement of user's head called "Sword of Damocles." Although size is large, but user has been exposed to interaction of handle. The Eye Phone, a virtual reality device developed by [8], became world's first market-oriented VR application area, and since 1990s, virtual reality technology has continued to develop. Computer hardware has been optimized, display resolution has been improved, and human-computer interaction system has been innovated and developed. As a result, VR devices have become more operable and experience has gradually increased. At same time, virtual reality devices have penetrated into fields of education, industry, culture and art [4],[5].

3 VIRTUAL VISUALIZATION TECHNOLOGY ARCHITECTURE

Virtual visualization has three main characteristics, namely "31" characteristics: Immersion, Interaction, and Imagination (Figure 1).

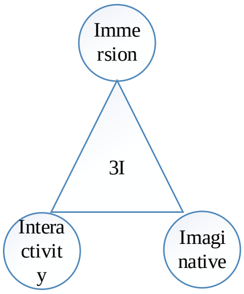

Figure 1: "3I" Characteristics of virtual reality.

The physical space and digital space influence and interact with each other, and together they constitute content of virtual visualization of red architectural heritage (see Figure 2). First of all, virtual building scenes are created by on-site research, mapping, photographing, drawing and modeling of physical buildings, and contents of virtual buildings can be updated according to restored and reconstructed physical buildings. Secondly, virtual buildings are used as basis for creating an archival information base of red architectural heritage. Finally, virtual scenes are created based on archive information database, and then virtual visualization of red architectural heritage is realized.

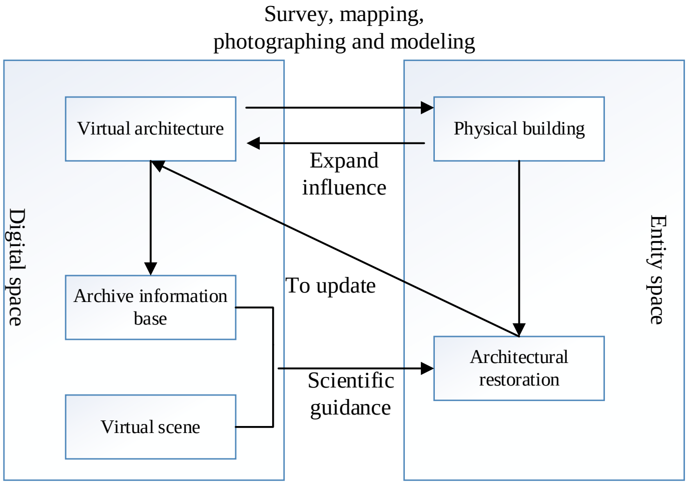

Figure 2: Composition diagram of virtual visualization.

The construction process of virtual visualization of red architectural heritage in a district of Shanghai mainly includes four steps: data acquisition and digital filing, three-dimensional model construction, virtual environment construction and virtual interactive design. Data acquisition and digital filing stage is basic stage of core process of virtual visualization. At this stage, we should first collect relevant information of buildings through field investigation and mapping, evaluate and classify their preservation, and then deal with all kinds of data collected. According to data collection results, information table of red Architectural Heritage Archives is formed. The three-dimensional model construction stage serves as a connecting link between preceding and following. It is necessary to use processed data information of red Architectural Heritage Archives in combination with 3D real map to construct three-dimensional model of relevant buildings, which specifically includes steps of model equal proportion restoration, material mapping processing, model optimization design and model archiving. At same time, it is necessary to consider design of virtual visualization module of docking model. The realization of virtual visualization is achievement stage. Based on establishment of three-dimensional model, construction of virtual environment and architecture is mainly divided into construction of natural environment and artificial environment, and then through corresponding software and hardware equipment, virtual visualization of red architectural heritage is realized. The virtual interaction design carries out corresponding module design for different service groups. This paper is divided into three parts: virtual roaming, virtual repair and virtual disassembly. The core construction process of virtual visualization is shown in Figure 3.

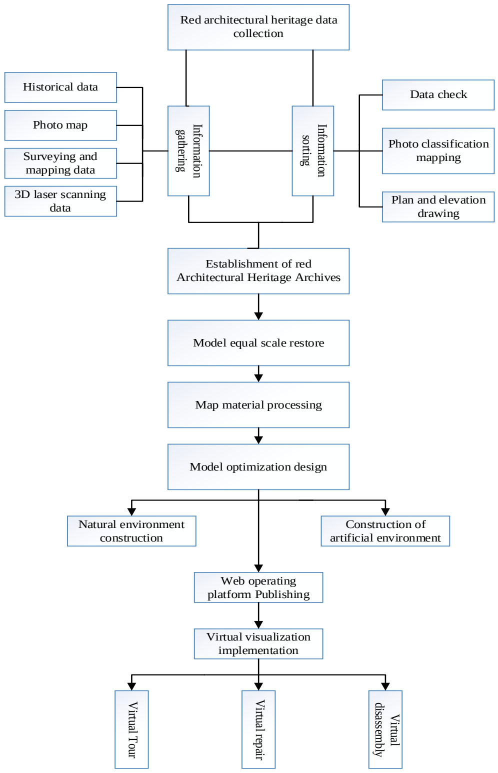

Figure 3: Flow chart of virtual visualization core construction.

Data collection and digital filing are basic stages of virtual visualization of red architectural heritage. The main method used for data collection is field investigation, and data collection mainly includes two stages: data collection and data processing. On basis of completion of data collection, red architectural heritage is assessed and classified, and red architectural heritage is digitally archived through file information table (see Figure 4).

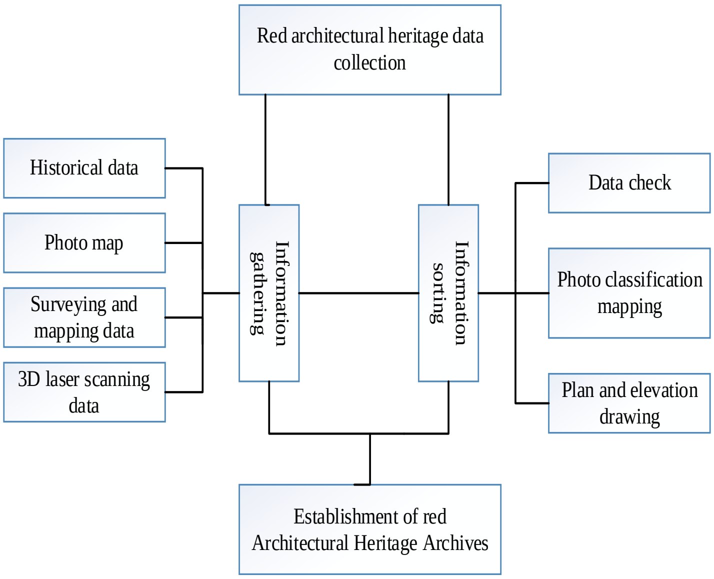

Figure 4: Flow chart of data acquisition and digital filing.

According to classification results, a corresponding three-dimensional digital model of red architectural heritage is established, which can correspond to different virtual visualization contents according to different types of three-dimensional models (see Figure 5). Among them, model is established based on classification of current status of red architectural heritage, and classification of virtual visualization module is mainly based on functional utilization of red architectural heritage.

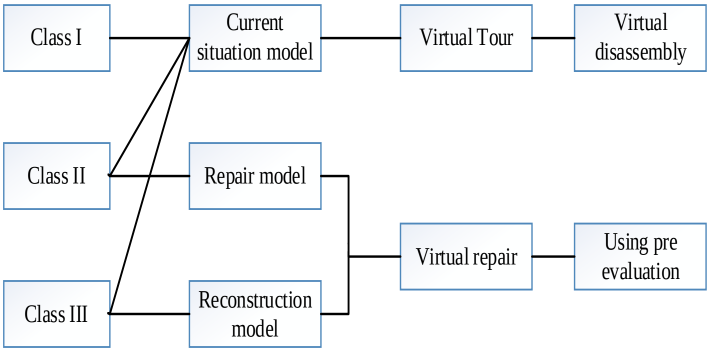

Figure 5: Application chart of overall assessment results of Handan's red architectural heritage.

Different types of service users have different needs, so virtual visualization design should be designed according to the characteristics of different service users (see Figure 6). virtual visualization is divided into three categories: virtual roaming, virtual repair, and virtual disassembly, and then detailed design is carried out for each category.

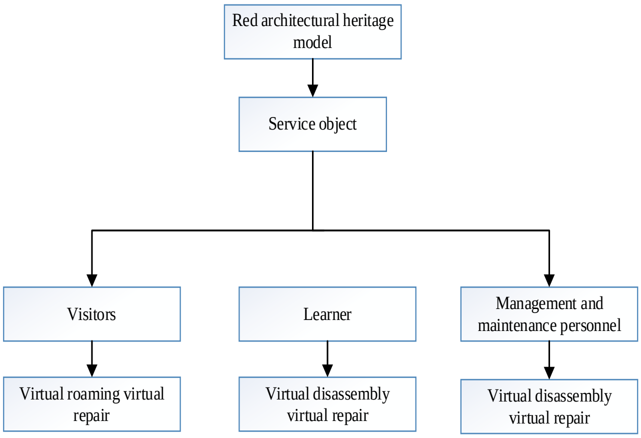

Figure 6: Virtual visualization module for different service objects.

The implementation of virtual visualization of red architectural heritage in Shanghai X area mainly includes three modules: virtual roaming, virtual restoration and virtual dismantling, and different virtual visualization modules use different methods, software and implementation processes (see Figure 7).

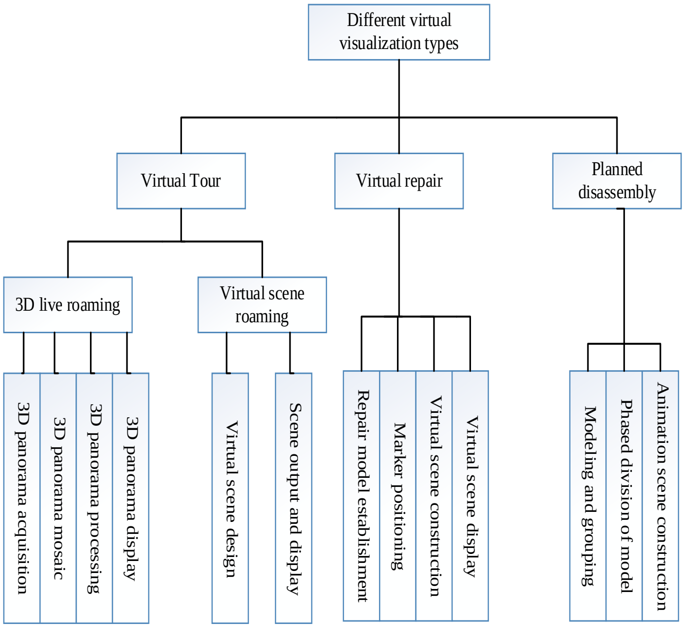

Figure 7: Implementation process of different virtual visualization types.

AR system structure is needed to realize AR virtual restoration effect (see Figure 8).

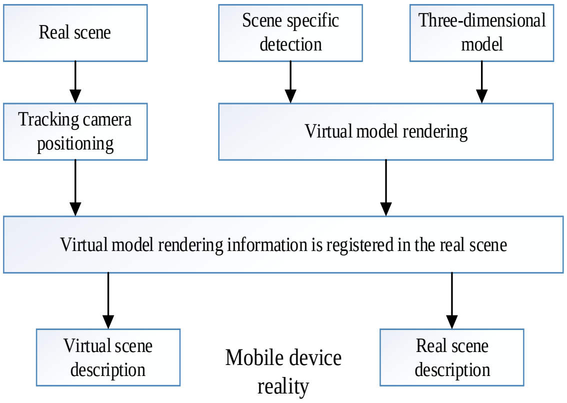

Figure 8: AR system structure diagram.

According to four modules of AR system, based on Unity3D+Vuforia technology platform, AR virtual restoration design process of red architectural heritage of a district in Shanghai can be divided into four steps: virtual restoration model establishment, Vuforia marker positioning, Unity3D scene construction, and AR virtual scene display (see Figure 9), and following subsections will elaborate operation of each step, so we will not focus on them here.

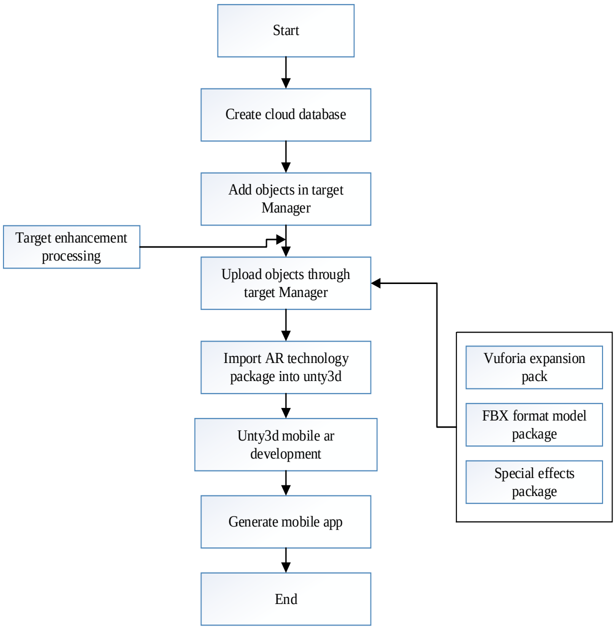

Figure 9: Uniy3D+ Vuforia platform AR virtual repair overall process.

4 EAC PROJECTION ALGORITHM

The calculation of WS-PSNR index is similar to that of SPNR index, and formula is as follows:

$$WS - PSNR = 10\log\left(\frac{MAX_I^2}{WS-MSE}\right) \tag{1}$$

Where WS-MSE represents weighted mean square deviation, and calculation formula is as follows:

Mn represents width and height of video image, $w(i,j)$ represents weight value at pixel coordinates (i,j) , and $I(i,j)$, $I'(i,j)$ represents corresponding pixel values on reference video and test video respectively.

$$WS - MSE = \frac{\sum_{i=0}^{M-1}\sum_{j=0}^{N-1}\left[I(i,j)-I'(i,j)\right]^2\cdot w(i,j)}{\sum_{i=0}^{M-1}\sum_{j=0}^{N-1}w(i,j)} \tag{2}$$

Different projection methods have different weight calculation formulas. For video, image size is $M \times N$ The weight calculation formula of ERP projection method of n is as follows:

$$w(i,j)_{CMP} = \left[1 + \frac{d^2(i,j)}{r^2}\right]^{-3/2} \tag{3}$$

Where $r = \frac{M}{2}$ next, $d(i,j)$ represents distance from point on square to center, and calculation formula is:

$$d(i,j) = \sqrt{\left(i + 0.5 - \frac{M}{2}\right)^2 + \left(j + 0.5 - \frac{M}{2}\right)^2} \tag{4}$$

Similarly, according to symmetry, weight distribution of six cube faces in EAC projection method is same. Suppose video image size of each face of cube is $M \times M$. Then weight calculation formula of EAC projection method is

$$w(i,j)_{EAC} = \frac{\pi^2}{16\cdot\left[1+\tan^2(t_i)+\tan^2(t_j)\right]^{\frac{3}{2}}\cdot\left[\cos(t_i)\cos(t_j)\right]^2} \tag{5}$$

The calculation formula of t_i , t_j is as follows:

$$t_i = \frac{\pi}{4}\cdot\left[\frac{2(i+0.5)}{M} - 1\right] \tag{6}$$

$$w(i,j)_{EAC} = \frac{\pi^2}{16\cdot\left[1+\tan^2(t_i)+\tan^2(t_j)\right]^{\frac{3}{2}}\cdot\left[\cos(t_i)\cos(t_j)\right]^2} t_j = \frac{\pi}{4}\cdot\left[\frac{2(j+0.5)}{M} - 1\right] \tag{7}$$

Similarly, according to symmetry, weight distribution of twenty triangular surfaces in CISP projection method is same. Assume that video image size of each face is m × N. Then weight calculation formula of CLSP projection method.

$$w(i,j)_{CISP} = \left[1 + \frac{d^2(i,j)}{r^2}\right]^{-3/2} \tag{8}$$

Where, $r = M/(4\sqrt{3}/(3+\sqrt{5})), \mathrm{d}^2(i,j) = (i + 0.5 - M/2)^2 + (j + 0.5 - 2N/3)^2$.

In 2001, ARVO proposed a general method [15] of area preserving mapping. According to this method, specific calculation formula of area stretching ratio ASR (U, V) at any point (T, V) on projection plane is as follows.

$$ASR(u,v)=\sqrt{\left(\frac{\partial p}{\partial u}\cdot\frac{\partial p}{\partial u}\right)\left(\frac{\partial p}{\partial v}\cdot\frac{\partial p}{\partial v}\right)-\left(\frac{\partial p}{\partial u}\cdot\frac{\partial p}{\partial v}\right)^2} \quad (9)$$

The expression of unit vector $\overset{1}{p}$ is shown in Formula 3. $\frac{\partial p}{\partial u},\frac{\partial p}{\partial v}$ are partial derivatives of unit vector $\overset{1}{p}$ to variables u and V respectively, which can be obtained by derivation

$$\frac{\partial p}{\partial u}=\frac{1}{(u^2+v^2+1)^{\frac{3}{2}}}\begin{bmatrix}-uv\frac{\delta q}{\delta u}+v^2\frac{\delta f}{\delta u}+\frac{\delta f}{\delta u}\\ u^2\frac{\delta g}{\delta u}-uv\frac{\delta f}{\delta u}+\frac{\delta g}{\delta u}\\ -u\frac{\delta f}{\delta u}-v\frac{\delta g}{\delta u}\end{bmatrix}$$
$$\frac{\partial p}{\partial v}=\frac{1}{(u^2+v^2+1)^{\frac{3}{2}}}\begin{bmatrix}-uv\frac{\delta g}{\delta v}+v^2\frac{\delta f}{\delta v}+\frac{\delta f}{\delta v}\\ u^2\frac{\delta g}{\delta v}-uv\frac{\delta f}{\delta v}+\frac{\delta g}{\delta v}\\ -u\frac{\delta f}{\delta v}-v\frac{\delta g}{\delta v}\end{bmatrix} \quad (10)$$

Where $\frac{\delta f}{\delta u}$, $\frac{\delta g}{\delta u}$, $\frac{\delta f}{\delta v}$, $\frac{\delta g}{\delta v}$ respectively represents partial derivative of distortion function FG to variable, V. By introducing above formula into formula 310 for simplification, calculation formula of area stretching ratio at any point (U, U) on projection plane is as follows.

$$ASR(u,v)=(u^2+v^2+1)^{-\frac{3}{2}}\left[\frac{\partial f}{\partial u}\frac{\partial g}{\partial v}-\frac{\partial f}{\partial v}\frac{\partial g}{\partial u}\right] \quad (11)$$

The distortion function of CMP projection is shown in formula 11. The distortion function, f, g is relative to variable v , u The partial derivative of is

$$\begin{cases}\frac{\partial f}{\partial u}=1\\ \frac{\partial g}{\partial v}=1\\ \frac{\partial f}{\partial v}=0\\ \frac{\partial g}{\partial u}=0\end{cases} \quad (12)$$

Therefore, calculation formula of area stretching ratio at any point (u,v) on CMP projection plane is

$$ASR(u,v)_{\text{cmp}}=(u^2+v^2+1)^{-\frac{3}{2}} \quad (13)$$

The distortion function of EAC projection is shown in formula 13. The partial derivative of distortion function f, g to variable v , u is

$$\begin{cases} \dfrac{\partial f}{\partial u} = \dfrac{\pi}{4\cos^2\left(\frac{\pi x}{4}\right)} \\ \dfrac{\partial g}{\partial v} = \dfrac{\pi}{4\cos^2\left(\frac{\pi x}{4}\right)} \\ \dfrac{\partial f}{\partial v} = 0 \\ \dfrac{\partial g}{\partial u} = 0 \end{cases} \tag{14}$$

Therefore, calculation formula of area stretching ratio at any point (v, u) on EAC projection plane is:

$$\begin{aligned} ASR(u,v)_{\text{EAC}} &= (u^2 + v'^2 + 1)^{-\frac{3}{2}} \cdot \frac{\partial f}{\partial u}\frac{\partial g}{\partial v} \\ &= \left(\tan^2\left(\frac{\pi u}{4}\right) + \tan^2\left(\frac{\pi v}{4}\right) + 1\right)^{-\frac{3}{2}} \cdot \frac{\pi}{4\cos^2\left(\frac{\pi u}{4}\right)}\frac{\pi}{4\cos^2\left(\frac{\pi v}{4}\right)} \end{aligned} \tag{15}$$

Inspired by Taylor expansion of trigonometric function, a generalized cube projection method based on polynomial approximation is proposed in this paper. In order to simplify calculation, we use univariate and odd order polynomials to represent distortion functions f and g of generalized cube projection method. Their expressions are as follows.

$$\begin{cases} f(u) = k_1 u + k_3 u^3 + \mathrm{L} + k_{2n-1} u^{2n-1} \\ g(v) = k_1 v + k_3 v^3 + \mathrm{L} + k_{2n-1} v^{2n-1} \end{cases} \tag{16}$$

Where n = 1,2,3, k_i is parameter of polynomial.

According to formula 3.18, partial derivative of distortion function f and g of n-order cube projection method to variables u and V is:

$$\begin{cases} \dfrac{\partial f}{\partial u} = \sum_{i=1}^{n} \left[(2i-1)k_{2i-1}u^{2i-2}\right] \\ \dfrac{\partial g}{\partial v} = \sum_{i=1}^{n} \left[(2i-1)k_{2i-1}v^{2i-2}\right] \\ \dfrac{\partial f}{\partial v} = 0 \\ \dfrac{\partial g}{\partial u} = 0 \end{cases} \tag{17}$$

Therefore, calculation formula of area stretching ratio at any point (U, v) on projection plane of n-order cube is

$$\text{ASR}\ (u,v)_{n-\text{CMP}} = (f^2 + g^2 + 1)^{-\frac{3}{2}} \cdot \frac{\partial f}{\partial u}\frac{\partial g}{\partial v} \tag{18}$$

For example, area stretching ratio is π/6 for bit spherical projection, and calculation procedure is shown below.

$$ASR = \frac{\text{Area (sphere)}}{\text{Area (cube)}} = \frac{4\pi}{24} = \frac{\pi}{6} \tag{19}$$

To reduce distortion of image in process of cube projection means to find a set of distortion functions f, g, so that area stretching ratio at any point (U, V) on cube surface is as close to $\pi/6$ as possible, that is, $ASR(U,V) - \pi/6$ is as small as possible. Sufficient sample points are evenly selected on cube surface, and distortion of projection method can be accurately quantified by calculating root mean square error of each sample point. In this paper, root mean square error E is used to represent distortion of whole projection method, and its calculation formula is as follows.

$$E = \sqrt{\frac{1}{M \times N} \sum_{i=1}^{M} \sum_{j=1}^{N} e_{ij}} \tag{20}$$

Where $e_{ij} = \left(ASR\left(u_i, v_j\right) - \frac{\pi}{6}\right)^2$ represents projection distortion at sampling point $\left(u_i, v_j\right)$, $M \times N$ represents number of sampling points on cube face.

5 RESULTS

At present, most of red architectural heritage information is classified according to way information is obtained, such as through mapping data to form drawings, taking photos and audio and video. Although this access method can ensure integrity and authenticity of architectural information, information is kept in different ways and is independent of each other, so it is tedious to go through multiple places when accessing a certain architectural information. In order to improve efficiency of archival access, information classification of red architectural heritage of Shanghai X district will be classified according to information content, which mainly includes physical information, historical information and human information of red architectural heritage of Shanghai X district (see Table 1).

Data information classification	*Humanistic information*
Entity information	*Building plan and facade, architectural style, architectural components, architectural decoration and sketch*
Historical information	*Building damage date, repair date, work content, etc*
Humanistic information	*Specific events of red revolution related to architecture*

Table 1: Classification of red architectural heritage data information.

According to different types of data information, corresponding information collection methods should be selected (see Table 2). The physical information mainly contains objective information such as specific dimensions of building, which requires precise data collection methods. Historical information records damage and repair information of red architectural heritage, which is an important factor in building information archives, so data collection method also needs to be precise. Humanistic information mainly records important historical, event or activity information related to red buildings, which can be accurately recorded through interviews, historical documents and real-life reproduction.

The assessment criteria of red architectural heritage in Shanghai X District can be set based on current preservation and functional use of buildings (see Table 3). Firstly, in terms of current state of preservation, red architectural heritage can be assessed in three aspects: plan layout, structural system and detailed components; secondly, in terms of functional use, original and modified use of red architectural heritage can be assessed. Each assessment can be divided into three categories: good, average and poor according to assessment basis [1],[24].

Collection mode	*Entity information*	*Historical information*	*Humanistic information*
Real reproduction	*Yes*	*Yes*	*No*
Literature review	*No*	*Yes*	*Yes*
Language record	*No*	*No*	*Yes*

Table 2: Selection of collection methods for different information types.

	Evaluation results	*Preferably*	*Commonly*	*Poor*
Preservation aspect	*Plane layout structural system Detail component*	*Save complete*	*Missing*	*Almost completely missing Serious damage Serious damage*
Utilization	*Original function Function of reformation*	*Retain original function completely, transform it into cultural activities such as exhibitions, and use it more frequently*	*Some of original functions are retained and transformed into cultural activities Which are used less frequently*	*No original function Retained without functional modification*

Table 3: Red architectural heritage evaluation criteria.

After overall evaluation of red architectural heritage of Shanghai X district, red architectural heritage of Shanghai X district was classified according to evaluation results (see Table 4), in which, model was established based on classification of current preservation of red architectural heritage, and classification of virtual visualization module was mainly based on functional utilization of red architectural heritage.

Plane layout	*Structural system*	*Detail component*	*Original function*	*Function of reformation*	*Evaluation level*
Preferably	*Good*	*Good*	*Good / average*	*Good*	*Class I*
Good / average	*Average*	*Average*	*Good / average*	*Average*	*Class II*
Poor	*Poor*	*Poor*	*Poor*	*Poor*	*Class III*

Table 4: Red architectural heritage classification table.

According to classification of composition of building, model of red architectural heritage of Shanghai X district can be divided into five parts: roof layer, beam frame layer, arch layer, decoration layer and column base layer. The roof is divided into ridge, rafters, tile surface, etc.; beam frame layer is divided into standard bars, beams, gourd columns, etc.; decoration layer is divided into wall decoration and beam frame decoration. In modeling, should be from bottom to top, from whole to local modeling, in accordance with building construction order, main structure of building model built such as walls, columns; secondly, building arch layer and beam frame layer for modeling; and then red building heritage decoration layer for modeling such as doors, windows, railings, etc.. The author takes an old site compartment as an example to show geometric shape modeling process (see Figure 10).

Figure 10: Geometric model building process.

When designing scenes in Twin motion, it is necessary to combine architectural information and human history information, and to be as close as possible to current state of building. When objects are simple, you can use materials, plants, terrain, people, vehicles, objects, lighting and other related vignettes in Twin motion software to add and combine; when objects are complicated, you can use other modeling software to make them and then import them into virtual scene, and you can also adjust weather, seasons, wind speed, etc. for building to finally get a complete 3D model of building the virtual scene of building (see Figure 11).

Figure 11: Virtual roaming scene design.

The display of VR red architectural heritage and its related cultural relics requires 3D scanning of them, obtaining real VR images and realistic textures of exhibits through computer processing, and realizing virtual exhibition of exhibits provided in form of fine three-dimensional models. Users can observe exhibits from different precision and angles, zoom in and out at will, or change perspective to suit needs of audience (see Figure 6-1). Since red architectural heritage is story-based, in order to show stories and activities related to buildings at that time more vividly, virtual animation display of red architectural heritage is needed, mainly by collecting historical information materials of buildings, videos, etc. to build virtual scenes and carry out animation design. By making content of display into educational courseware, we can increase visitors' interest in learning about red architectural heritage and achieve learning purpose in process of entertainment.

Figure 12 (a) Virtual tour map

Figure 12 (b) Virtual roaming map

Figure 12: Virtual roaming system display.

In order to bring a better experience to visitors, digital physical interactive display of red architectural heritage can be carried out. The digital somatosensory interactive system consists of a large interactive platform hardware system and a multimedia presentation software system based on multi-touch technology. The viewer can stand on either side of interactive platform and use finger movements and clicks to provide independent interaction with multimedia content. The system uses a combination of projector and shaped projection desktop as presentation terminal, mainly including integrated integration of related equipment, such as projector, edge fusion processor, control host, focus audio, finger touch image, etc. The interaction of multi-person multi-point display interactive platform system is divided into contact and non-contact, and interaction position range of projected image is called hot spot area. When viewer's hand touches hot spot area, image in hot spot area will change and corresponding interaction information will be displayed in a pop-up window or prompt. Depending on content, hotspot can be displayed anywhere on projection screen, allowing viewer to use system easily and flexibly. The physical interactive system allows visitors to freely enjoy exhibition content related to Red Architectural Heritage on screen, rotating and zooming exhibits from all angles without need to touch device. The system enhances visitor experience, enriching content and format while maximizing curiosity of visitors and learning.

6 CONCLUSIONS

When technology and art are intertwined, there is always topic of research content. In this paper, we conducted a systematic study on digital archiving and virtual visualization method of red architectural heritage in X district of Shanghai, and constructed a digital virtual visualization model of red architectural heritage using virtual technology with 98.3% simulation degree, which further enhanced people's awareness of red architectural heritage protection and promoted spirit of red culture. In future, interactive art of virtual reality technology will be supported by technology, and there will be a large number of products to break gap between virtual and reality, so that virtual and reality can be integrated.

Kangkang Zhange, https://orcid.org/0009-0007-8662-7734
Jun Fan, https://orcid.org/0009-0000-7203-2253

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