Design Studies and Intelligence Engineering
L.C. Jain et al. (Eds.)

doi:10.3233/FAIA220706

A Review of Virtual Display Construction Methods

Zhicheng LAI, Jue WU [1], Xiaoyue XING, Biling WANG
Art and Design Institute, Zhejiang Sci-Tech University, Hangzhou, China

Abstract. The purpose is to analyze the constructive approach of virtual digital display and its research status from the technical perspective, and to provide strategic ideas for the development of virtual digital exhibition. The methodology firstly starts from the concept of virtual digital exhibition, collects and organizes the application areas of virtual digital exhibition; secondly, identifies the composition of virtual digital exhibition system categories and technical support, summarizes the advantages and disadvantages of different categories of digital exhibition; points out the limitations of the current existence, outlines the challenges of the research and puts forward development suggestions. The conclusion outlines the virtual digital display building methods and presentation forms, analyzes the characteristics and development trends of the three building types, and enhances the presentation forms of virtual displays.

Keywords. Virtual Digital Display, Build Method

1. Introduction

With the high development of information technology and the popularization of the concept of "Internet of Everything", the digital expression of display design has become one of the development trends in its field. Virtual digital exhibition as its carrier has a more flexible form and permanent preservation characteristics to show multiple values. Visitors can feel the new technology, new concept and new method of design through the virtual construction environment and get a new sense of immersion experience from it.

Virtual digital display is the link in information interaction design, which is the direct bridge between online exhibits and users. It conveys the intuitive visual feeling to the viewers with direct information, including factors such as information design, layout design and color style design. This paper analyzes the category composition of the contemporary virtual graduation exhibition, outlines the technical means of constructing different digital displays respectively, compares the advantages and shortcomings of display design, building mode and display characteristics under different digital means by comparing the application cases of virtual digital exhibition at home and abroad, and puts forward development suggestions.

[1] Jue Wu, Universal Design Institute, School of Art and Design, Zhejiang Sci-tech University; E-mail: wj5277@zstu.edu.cn.

2. Virtual digital exhibition introduction

Virtual digital exhibition is a kind of rich media network interactive platform, also known as online exhibition, virtual exhibition, cloud exhibition, etc. It uses digital means to transform physical exhibits into data resources and realize cross-time and cross-territory dissemination through virtual cyberspace [1]. Virtual digital exhibition has been proposed around 2000 at the earliest [2], but the development was slow due to the limitation of the Internet at that time in terms of transmission rate and storage volume of graphic files. In recent years, there have been a number of domestic policies on virtual digital exhibition, in January 2022, the State Council "on the issuance of the" fourteen five "digital economy development plan notice" pointed out that deepen the integration of AI / VR and other technologies, expand the public life application scene, improve the digital level of public services. This means that the digital display form has become a hot trend nowadays [3]. With the development of economic level, people's demand for spiritual and cultural aspects is increasing, and their pursuit of experience and personalization of visiting virtual digital exhibition is enhanced. Catalyzed by the new crown pneumonia epidemic factor, the physical isolation state has pushed the development of virtual digital exhibition to a climax, and various types of virtual digital exhibition technology and display methods are becoming increasingly mature[4].

3. Virtual digital exhibition construction type

According to the information characteristics, situational needs and functional applications presented by different categories of exhibits, all influence the construction form of virtual digital exhibition. At present, the basic digital display forms that the public is exposed to can be roughly divided into three categories, the first one is the interactive catalog of graphics and text presented in a card-type layout; the second category relies on 3D software modeling to replicate or create virtual scenes; the third category is to capture physical scenes through 360° panoramic photography technology. The three categories of virtual digital exhibition are not fragmented or opposing, and many virtual digital exhibitions at home and abroad are constructed by integrating two or more ways of display to provide different participation experiences to the viewers[5].

Table 1. Virtual digital display types

Type	Build Technology	Environmental construction method	Equipment	Charting method	Display Features
Graphic Interactive Catalog	Web Development	No environment	Computer	2D image, text, audio	Highlighting exhibit information
Three-dimensional software modeling	Web3D	Virtual environments create, replicate reality	Computer	3D models, images, text, audio	Focus on immersion
360° panoramic photography	Panoramic photography techniques	Replicating reality	Camera	2D image stitching into 3D environment	Emphasis on authentic experience

3.1. Build Technology

The three different display methods use different building technologies. From the technical point of view, we can divide them into web front-end development, Web3D and panoramic image stitching, and these three types of technologies also reflect different features and functions respectively.

3.1.1 ．Web-based front-end development

Graphic-interactive catalogue is the most common display mode in virtual digital exhibition. This kind of display mode does not construct a virtual environment, and card-type design layout is commonly used, so strictly speaking, it belongs to the category of web design. Card design originated from all kinds of objects in human life at the earliest, and the card in web design is considered as an extension of the material in real life to the virtual world [6]. The front-end development technology of the interactive catalogue is mainly composed of HTML, CSS, JavaScript, DOM and AJAX [7] (see Table 2). Because of its stability and convenience brought by its technical characteristics, it has been adopted by major virtual digital exhibitions.

Table 2. Web front-end development technology

Technology Name	Definition	Functional role	Features
HTML	Hypertext Markup Language	Describe the content of the page	Simplicity, extensibility, versatility
CSS	Marked language	Designing web styles	Cascading, inheritance, prioritization
JavaScript	Interpreted programming languages	Advanced web effects creation	Dynamic, versatile
DOM	Document Object Model	Define standards for accessing and manipulating HTML documents	Ease of use
AJAX	Creating fast dynamic web languages	Implementing asynchronous web page updates	Asynchronous submission

HTML, CSS, and JavaScript, as the pillar languages, play a very important role in the whole process of building the front-end development of interactive graphic catalogs, and take on different tasks respectively. HTML is a markup language created by Tim Berners-Lee and Daniel W. Connolly, the inventors of the Web, for constructing and presenting web content, with the main functions of adapting hypertext structures, correcting images, and rendering dynamic and static effects[8]. The main functions include adjusting the hypertext structure, correcting images and rendering dynamic and static effects. This is done by linking the text, images, animations, audio and other separately scattered information to be presented in the virtual digital exhibition in different cards, connecting them into a logical whole and giving the viewer a smooth interaction process. CSS (Cascading Style Sheets) is a markup language that prefers to control the appearance of web pages [9], such as the layout arrangement of cards in the web, font style specification and style design, and is the most direct visual feedback in

virtual digital exhibitions. In its technical form, it isolates content and formatting, facilitating the maintenance and updating of web pages and increasing the transmission rate of web pages; JavaScript enables the real-time expression of interactive effects. As an interpreted programming language [10], JavaScript is widely used in dynamic design to highlight embellishment effects, such as image text sliding zoom, page animation interpolation, page loading refresh, etc., to assist the viewer in getting a better visual effect of the interface, and also to reduce the pressure on the server port and improve user efficiency; DOM is called the Document Object Model [11], and is recommended by the W3C organization The standard programming interface for processing extensible markup languages (HTML or XML), through these DOM interfaces can be reworked web content, structure and style, to enhance the direct connection of web pages; AJAX is a technology for creating interactive web application development [12], the main function is reflected in the asynchronous interaction - that is, the client sends After a request is made, a second request can be made without waiting for the server to end accordingly. This means that it is possible to update part of the web page without reloading the whole page, thus improving the efficiency and stability of the web operation.

The type of virtual digital exhibition consisting of a card-type layout with five technologies has been used in numerous applications at home and abroad. For example, the online digital exhibition of Xi'an Academy of Fine Arts 2022 (Figure 1) uses cobalt blue as the background layer, with six rectangular images in the form of cards in each row and columns, and illustrates the specific information content of the exhibits by matching the text description at the bottom; the digital exhibition of Van Gogh Museum in Amsterdam arranges nearly 1,500 works of Van Gogh in the form of rectangular arrays, keeping small white space between each rectangle and presenting the information of the works in white characters in the The Guangzhou Academy of Fine Arts uses nearly 1,000 photos of teachers and students to display information in a hovering card arrangement; the Orsay Virtual Digital Exhibition in Paris also uses a rectangular array arrangement, but differentiates in the shape of the cards, which are similar in shape but not necessarily identical.

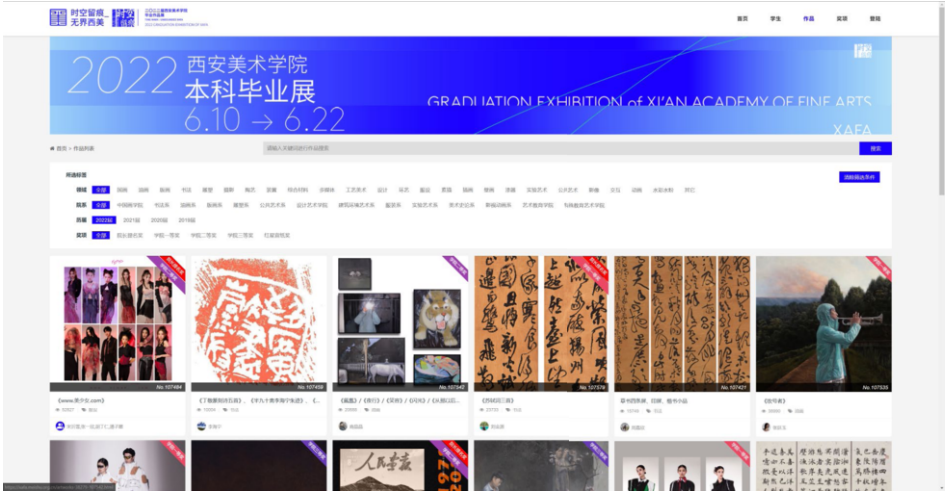

Figure 1. Xi'an Academy of Fine Arts 2022 Online Digital Exhibition.

In addition to the card display form, the virtual digital exhibition of major platforms also presents completely different patterns in the design of dynamic interaction methods. For example, the 2022 undergraduate digital exhibition "Generate" of Beijing Institute of Fashion is divided by a neat black and gray block, with different color and size of the card information scaled to enter, through the interactive click on the background to enter the graduation works display area of different majors. In this block, not all the works are completely laid out, but some cards of different sizes are presented at irregular intervals, and the rest of the displayed works are arranged in the form of numerical numbers. When moving the cursor to the corresponding number, the works displayed in this area slide out with dynamic effects (Figure 2), and when clicking into the next level of information, the works' introduction and related details are clearly displayed.

Figure 2. Beijing Institute of Fashion 2022 Online Digital Exhibition.

3.1.2 . Based on Web3D technology

Building the exhibition hall into a virtual environment for visitors to roam in a panoramic way is also the main display means used by major curatorial platforms in recent years, mainly relying on Web3D technology - the product of combining Web technology and 3D modeling technology [13]. Through Web3D technology, visitors can browse the 3D virtual environment in the form of a web page, which has a higher sense of presence and more interactivity than a graphic interactive directory, and does not require the use of special hardware and professional equipment.

Web3D technology, also known as Web 3D technology, can be traced back to the Virtual Reality Modeling Language (VRML).In 1998, the VRML Association changed its name to the Web3D Association, completing the conversion from WRML to Extensible 3D (Extensible 3D Language) [14], and The term Web3D was first used [15]. In recent years, with the continuous development and evolution of Web3D technology, it is also widely used in games, business, education, medical and other fields. The current Web3D technology composition presented can be roughly divided into VRML, Cult3D, Java and so on [16].

VRML is a modeling language for building real-world or virtually constructed scenes. Its objects are called nodes, and a collection of child nodes can form complex scenes that can be defined to create dynamic virtual worlds. VRML was first introduced at the first WWW conference in Geneva in March 1994, and the VRML 1.0 standard was announced at the second WWW conference in Chicago in October of the same year. The VRML 2.0 standard, adopted in August 1996, complements and improves on VRML 1.0, not only making 3D scenes more realistic, but also adding interaction, animation, programming, and protoform definition functions[17]. In September 2000, the VRML2000 international standard (draft revised version) was released, thus, virtual reality technology entered a new era of development; Cult3D technology mainly consists of two parts, one part is used to edit 3D material, the other part is used to interpret the material, and finally the result is seamlessly embedded into the web page, its innovation lies in the use of existing technology and programming language to improve the display Its innovation is to use existing technology and programming language to improve the display quality and display speed. In addition, Cult3D files have small memory and strong interactive effect [18]. Java technology is a powerful Web programming language, which can create 3D objects and build scenes through Java technology. The main technical advantages are simple operation, easy browsing, good security, and the core of its technology is embedded in web pages through Apple, so there is no need to install any plug-ins.

For example, 2022 Zhejiang Sci-Tech University Graduation Exhibition (Figure3) is based on VRML to construct a virtual 3D space, using existing network technology and powerful 3D engine software to build interactive 3D objects on the web page[19], and using HDRP high-precision rendering technology to create the spatial atmosphere of the virtual exhibition hall, and the viewers can click on the interactive hotspots in the virtual exhibition hall to roam the whole house and view exhibit information; in In the virtual graduation exhibition of Nankai University, in addition to the basic interactive behaviors, a guide map is also added, which is more conducive to the location of exhibits and the acquisition of information by the viewers.

Figure 3. Zhejiang Sci-Tech University Graduation Exhibition.

Ali cloud in order to create a three-dimensional immersive digital exhibition hall in the front-end implementation of the three-dimensional exhibition hall and transition animation composition structure. Unlike other virtual digital exhibition halls, in order to ensure the authenticity of the viewer's perspective experience, Ali Hybrid Cloud platform provides to the interactive browsing method can only slide the left and right perspective. This way of processing can avoid to the greatest extent possible the virtual environment in a large perspective brought about by non-real experience. Therefore, the designer in the C4D engine software designed by the three-dimensional scene perspective (Figure 4) is a line trajectory. When the transition animation is switched, the pre-rendered video is linked to each spatial scene, and the transition video covers the short white screen and data loading state when the page is jumped, which can ensure the viewers to get a coherent experience process. In addition, in order to ensure that viewers lose users due to the long loading time of the model, Ali Cloud changed the scene rendering to mapping, and strictly controlled the size of each scene mapping to about 300KB, by limiting part of the interaction capability to achieve the balance point of the selected effect and performance, but the response exhibition and technical team in the exhibition architecture and development process have high requirements. Ali hybrid cloud platform has thus become a classic case of virtual digital display at the moment, and also provides a reference model for future virtual exhibition displays.

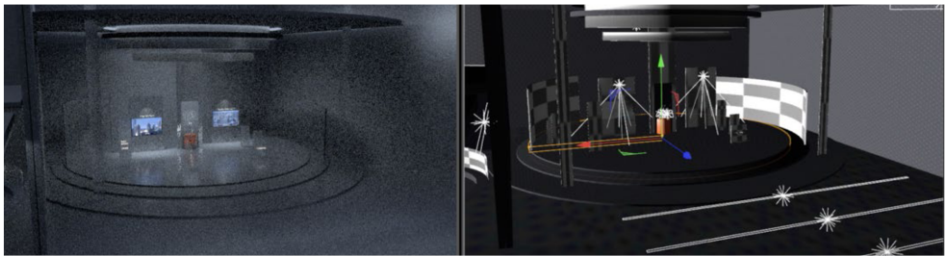

Figure 4. Ali cloud 3D digital exhibition hall scene design.

In order to meet the current cultural needs, many platforms have been created in China to provide curators with convenient and efficient channels for exhibiting according to different applications and interaction methods (see Table 3).

Table 3. Domestic 3D roaming curation platform

Platform Name	Positioning	Functional Features
Pingxing spreading lines	Platform of commercial nature, providing online art exhibition and college graduation exhibition construction services	Exhibit hall template, exhibit information list, graphic audio
Kujiale	Commercial nature platform, applied to interior home decoration, landscape design and other fields	3D model display, graphics and audio, exhibit interaction, navigation functions
MICE Cloud	Business nature platform, applied to business meetings, trade matching field	Graphic Audio
Shangdi 3D	Commercial nature platform, applied to industrial product display, environmental display	Virtual character walking, navigation functions, graphics and audio, exhibit interaction

Jimu	Platform of commercial nature, offering product manuals, online launches and other services	3D model interaction, free walking, graphics and audio, exhibit interaction
Zhiliao cloud exhibition	Public benefit nature platform, applied to all types of exhibition construction	Scene templates, graphic audio
Dayu cloud exhibition	Commercial platform, providing online exhibition services for artists to create their works	Includes graphic audio, automatic wayfinding, and audio explanation

3.1.3 . Based on panoramic photography technology

Panoramic photography is a photographic technique that gives people a three-dimensional feeling of real 360° all-round image, which is also known as spherical panorama [20]. Unlike wide-angle photography, it uses a professional panoramic camera combined with a panoramic head to capture image information of the whole scene, and then uses image stitching technology to combine several images with overlapping parts into one large seamless high-resolution image[21], followed by digital information processing of the image and adding browsing interaction hotspots, so that users can control the direction of the circular view and perform other interactive behaviors such as zooming in and out with the mouse. In 1998, mathematics professor Helmut Dersch developed a set of software to solve panoramic image stitching, but it was only a set of program code library and had no easy-to-use image interface itself. As the technology continued to evolve, a series of stitching software was created. The synthesized virtual scenes are more immersive and realistic than those built on Web3D technology [22]. From the technical point of view, panorama technology is also divided into spherical panorama, column panorama, cube panorama and object panorama[23], and curators can choose the composition of panorama technology according to different demand categories (see Table 4).

Table 4. Panorama Technology Category

Category Name	Object	Scope of presentation
Spherical panorama	Shooting environment	Horizontal view is 360°, vertical view is 180°
Columnar Panorama	Shooting environment	Horizontal 360°, restricted vertical view, only left and right sliding
Cube panorama	Shooting environment	Horizontal view 360°, vertical view 360°
Object Panorama	Photographing exhibits	3D exhibits that can support 360° rotation observation

For example, the "Panorama Palace" (Figure 5) online digital exhibition launched by the National Palace Museum is based on the construction mode of virtual display of still images of panoramic photography on a computer platform. So far seven years of iterations, from the initial version of the simple panoramic photo album to add maps and other functional optimization and now the panoramic Forbidden City. Not only has the content added rich cultural materials, but also the interactive functions have been continuously innovated to make the exhibition experience more diversified.

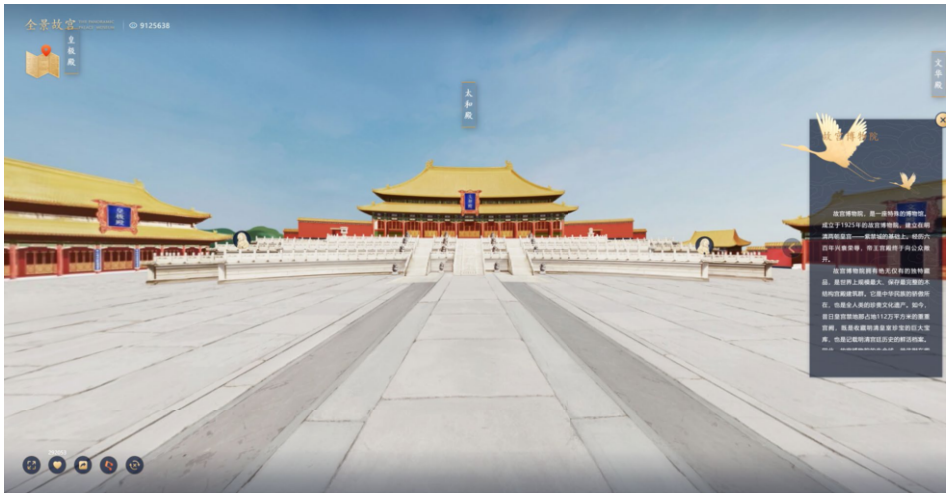

Figure 5. Panorama of the Forbidden City" digital exhibition of the National Palace Museum.

3.2. Environmental construction method

The construction method of the environment in virtual digital display can be currently divided into two categories [24]: virtual environment creation refers to the creation of an exhibition space that does not really exist, and replication of reality refers to the replication and migration of offline physical exhibition halls in the virtual environment.

Developed with Web3D technology, the Mercury Art Museum's digital exhibition hall is a representative of virtual environment creation. Inspired by the movie 2001 A Space Odyssey (Figure 6), the Mercury Art Museum uses the movie's circular space station as a design element to make the entire exhibition hall a spiral layout space. In the design of the pedestrian flow line, the traditional viewpoint of the exhibition is abandoned, simulating a gravity-free wandering around in space, and all exhibits are suspended around the space, reaching a fixed viewpoint through interactive clicks.

Figure 6. Mercury Art Museum Digital Exhibition Hall.

The Dunhuang murals began digital research in 1993, and a series of panoramic murals introduced by the Dunhuang Research Institute using panoramic photography replicates the way realistic environments are constructed. The high-precision collection stores colorful and realistic information about Dunhuang Grottoes' precious artifacts, effectively contradicting environmental cave conservation and utilization. Visitors can immerse themselves in the Dunhuang Grottoes online and see the lifelike murals [25], reducing the damage done to the caves by the large number of offline visitors.

3.3. Software and equipment carriers

Today, three types of displays - interactive graphic catalogs, 3D software modeling and 360° panoramic photography - can be viewed on smartphones, tablets and computers, and virtual scenes can be experienced by simply clicking on web links or scanning QR codes shared by curators.

In the process of building the three display methods need to use computer equipment to run the required software tools, for example, the front-end development tools needed for the graphic interactive directory: Microsoft's Visual Studio Code, Jetbrains' WebStorm, Github's Atom and DCloid's HBuilder developed by DCloid, etc. In 3D software modeling, 3D software such as Maya released by Alias, 3D Studio Max by Discreet, Lightwave 3D by Newtek, Rhino by Robert McNeel, etc. are often used to build complex environments; while 360° panoramic photography need to use panoramic stitching tools to complete the display build, such as PTgui from New House, Hugin developed mainly by Pablo d'Angelo, and Adobe Photoshop Lightroom developed by Adobe. From the hardware point of view, the process of building these three types of displays requires a highly configured running environment for front-end development and real-time generation and rendering of realistic virtual scenes, so they have high requirements for computer hardware facilities such as graphics cards, CPUs, motherboards, and memory.

In addition, panoramic photography also requires hardware equipment such as cameras to assist in the picture acquisition process. Both digital SLR cameras and traditional SLR cameras can take panoramic pictures, and it is worth mentioning that the image files taken by digital cameras can be used directly, while the film used by traditional cameras needs to be developed and scanned after shooting. In addition, the panoramic head also plays a role in the shooting process that cannot be ignored. The panoramic head is a device that carries the camera and other shooting equipment, and can fix the lens node on its rotation axis to ensure that each image made by the camera rotation is on the same node, so as to form a good panoramic picture.

3.4. Demonstrate messaging characteristics

Different display methods highlight different display advantages. In the curatorial process, the team should choose the display method according to the characteristics to be expressed.

3.4.1 . Graphic Interactive Catalog - Emphasis on exhibit information

To convey the information of the exhibits to the visitors is the most basic meaning in the virtual digital exhibition, and to deliver the information of the exhibits to the visitors

effectively is one of the urgent issues that the curatorial team needs to think about nowadays [26].

The card-based layout of the interactive catalog is essentially a web design, the core of which is to provide a clear presentation of the product to convey information to the viewer. Good visual guidance is required to enhance the visitor experience and user stickiness. Here, visuals, layout, color scheme, font size, and other factors all have an impact on the user experience. Any element and design of the interface affects the viewer's intuitive feeling of the virtual digital exhibition [27]. The card-style flat style abandons a lot of decorative effects and keeps the boundaries of all elements neat and clean, without any gradient or feathering. It highlights the simplicity of colors, the simplicity of elements and the readability of information, and the reason for this is to better handle the collection of information. Its design layout collects the information required to be expressed by each exhibit in the card, thus forming a natural break with other contents in the interface, which makes it easier to form an independent visual focus. The viewer can easily select the content of interest through the card, and no information confusion will arise even when browsing quickly. For example, Behance, a design and creative platform well known to designers, uses a card-based layout to create an intuitive user interface. Such a display design layout can make visual unity on the one hand, and on the other hand, it can help the viewer to browse more efficiently and reduce the interference of other factors when reading information. Do the independent focus of exhibition information. Presenting a card-style layout of the graphic interactive catalog in the digital display focuses more on the expression and transmission of information, making the interface information clear and aesthetically pleasing to design. Setting up the interface through the card characteristics reduces to a certain extent the cognitive burden that may arise during the interaction of the viewer, but because it does not create a specific environmental atmosphere, it also lacks the sense of presence and immersion in the virtual experience.

3.4.2 . Three-dimensional software modeling - Emphasis on space atmosphere

Web3D virtual digital exhibition mainly focuses on the creation of spatial atmosphere compared with the Graphic Interactive Catalog, which creates an immersive experience for the visitors by simulating objects and environment in the digital space. Web3D virtual exhibition hall can build the environment with narrative approach [28], specifically in the construction of scene model, simulation of material details, background music and expression of lighting layout to render the story background, use function and other information of exhibits. Immersion and interaction are the basic elements of the experience [29], and the construction of the virtual environment gives the viewer more options for free interaction, but it is not particularly intuitive for the readability of information. As the viewer exists in a virtual digital space, navigability also has a great impact on the user's experience, usually facing misdirection and inability to determine the current location, etc. The reasons for this can be divided into several points: 1. In the process of switching exhibition areas, the visual after switching is not consistent with the viewer's expectations. The curators often face the exhibits they need to display when setting the camera's entrance perspective, instead of changing the orientation perspective before switching, which is conducive to focusing on the exhibits' content, but the inconsistency between the perspective and behavioral expectations during the switching process will easily lead to the viewers' unfamiliarity and isolation [30]. 2. The same appearance of the interactive orientation in the front and back directions, without

differentiating the contents already browsed, will also 3. the distortion of the transition process of switching perspectives and the poor control of the marching process will also distort the spatial perception of the viewers.

3.4.3 . 360° panoramic photography - Emphasis on demonstrating authenticity

The virtual digital exhibition composed by 360° panoramic photography technology can save the cost of geometric modeling which requires a lot of labor work and is relatively difficult to operate and less costly to produce. The panoramic digital exhibition hall based on the synthesis of physical photography has a sense of realism that the other two categories cannot have, and can completely replicate the details and materials of specific exhibits and environments, thus avoiding possible deviations due to technical operation. Therefore, this type of display method is mostly used in the fields of cultural relics and architecture to complete the perfect reproduction of historical works. In addition, high-precision dynamic images can achieve a maximum magnification of more than 10 times, while the graphics built by Web3D are limited by the loading time, program and other factors to support only 2-3 times the zoom ratio[31], resulting in blurred pictures, low definition and other series of problems.

4. Current Issues and Future Directions

Virtual digital display is regarded as the best remedial strategy under the impact of the epidemic and is a special means to expand the information on the content of exhibits. As the application of virtual digital display continues to deepen, the requirements for the display effect presented by it are getting higher and higher. At present, there is a large gap between the curatorial situation and the development level of major virtual digital exhibitions, and the phenomenon of unbalanced and inadequate development is more obvious. The integration of technology application and display content is rigid, and the phenomenon of homogenization is seriously widespread, which leads to a distance between the publicity effect and the actual effect that is difficult to bridge, losing its proper value expression and cultural transmission, and limiting the experience given to the viewers [32]. This experience will directly affect the closeness and permanence of the relationship between the product and the viewer, leading to a reduction in public participation and affecting the social benefits of the exhibition. In addition to the subjective reasons of the curatorial team, the technical expression and realization are the important factors affecting the quality of the virtual digital display. How to improve its display quality has triggered a multi-dimensional thinking on virtual digital exhibition.

4.1. Construction of complex and realistic virtual environments and management of large amounts of data

The complexity and realism of the environment in today's virtual digital displays are increasingly demanding, and the key to solving this problem is the important task of modeling research, which depends on the further improvement and optimization of the performance of computers and specialized processing components; the development of better and more automated software tools, while the complex and realistic virtual

environments possess or distribute huge amounts of stored data, of which the effective scheduling, retrieval and maintenance is also a challenging issue.

4.2. Modelability, model complexity and usability

The 3D modeling virtual digital display method presents objects in the virtual environment to the viewer through digital modeling, but not everything can be represented through the model. For example, liquids, gases, grass and leaves, etc. The first is reflected in the complexity of the model, in the three-dimensional modeling process, the object consists of a polygonal surface, the so-called face number. In order to approximate the real scene, in the process of making a single vegetation or other complex models, often need to arrange a higher number of faces to achieve the desired effect, but the higher the number of faces of the model leads to a large amount of computer calculations, easy to cause the phenomenon of lag affects the viewing experience, such as grass, plants and other layout furnishings. In addition, objects without tangible forms are also difficult to present realistic effects by means of 3D modeling, such as liquids, gases, etc. Although the geometry can be simplified through the geometry of its appearance, but the simplified model and other exhibits in the virtual environment, the adaptability of the model has become an urgent problem to be solved.

4.3. Accuracy of image matching

The image stitching technology utilized in panoramic photography has become increasingly mature since the concept was proposed, but it still faces some problems that need to be solved: in the image stitching process, the processing speed is slow for high-quality images; the number of feature points detected in the feature detection process is too large for high-precision images, and there are even wrong feature points; for images without obvious features in the stitching process, there are matching errors and other situations occur. For simple grayscale images, the stitching effect is good, but for complex color images, there may be obvious edge gaps. All these problems affect the effect presented to the viewer, therefore, in order to stitching technology research focus, excluding the study of the speed of matching operation, to provide stitching algorithm operating efficiency, but also need to focus on how to improve the matching accuracy and other issues.

4.4. Innovative display methods

While meeting the basic information acquisition needs of the visitors, the exhibition activities also need to mobilize the active participation of the visitors, so that the visitors do not passively visit but actively experience the displayed contents. To understand the exhibits through interactive behaviors in a virtual environment, it is necessary to innovate the display methods, break the previous single static display method, and let the viewers receive information from real experiences and interactions. To this end, the curatorial team needs to establish a bridge between the exhibition and the viewer, highlight the interesting and interactive nature of the displayed content, and meet the needs of different viewers.

5. Concluding remarks

This paper reviews the three mainstream virtual display forms from the perspectives of virtual display building methods and presentation forms, focuses on comparing the differences, advantages and disadvantages of the three types of technologies in the virtual environment of building, input, presentation forms, systems, analyzes the current problems and challenges faced by the virtual digital exhibition and proposes future development plans.

Funding

This research is supported by the 2022 Higher Education Scientific Research Project Funded by Zhejiang Sci-Tech University: Research on Digital Virtual Simulation in Co-creation Mode" and "Key Project of Zhejiang Sci-Tech University's 2022 School Education Reform: Design Major Graduation Design Virtual Simulation Display Design Exploration Research".

References

[1] Qi Wang, The use and exploration of experience design in digital museums - a case study of the virtual exhibition hall of the National Museum of China, *Zhuangshi* 2020(02), 134–135.
[2] Yanbing Liu, Opportunities and challenges of cloud exhibition under the epidemic, *Beauty and Times (City Edition)* 2021(03), 88–89.
[3] Lijuan Zhang, Jia Lv, An analysis of the effect of "cloud exhibition" in museums during the epidemic, *Artifact Identification and Appreciation* 2020(17), 146–147.
[4] Yizhi Zhang, Jiancheng Huang, Logical Strategies and Design Translation of Virtual Digital Exhibitions - Taking the Online Graduation Exhibition of Global Art Schools 2020 as a Clue, *Art and Design Research* 2020(05), 65–72.
[5] Wu Y, Jiang Q, Liang H, Ni S. What Drives Users to Adopt a Digital Museum? A Case of Virtual Exhibition Hall of National Costume Museum, *SAGE Open 2022*(01).
[6] Wenzhe Yan, Research on the use of cards in mobile UI design, *Western Leather* 2020,42(08), 41–42.
[7] Li Jiang, Research on dynamic web front-end development technology and optimization strategy, *Digital Technology and Applications* 2018,36(03).
[8] Youbing Zhu, Application of VRML virtual reality technology in mechanical design, *Proceedings of the 2nd International Conference on Materials Engineering and Information Technology Applications 2016 (MEITA 2016)* 2016, 64–67.
[9] Tao Du, Application and optimization of CSS technology in web design, *Journal of Changzhi College* 2007(05), 35–37.
[10] Yafei Song, JavaScript effects in corporate website design, *Wireless Internet Technology* 2022,19(02), 91–92.
[11] Xiaodong Li, Yuqing Gu, DOM-based Web information extraction, *Journal of Computer Science* 2002, (05), 562–533.
[12] Lizheng You, Yuchun Guo, Chunxi Li, The principle and application of Ajax engine, *Microcomputer Information* 2006, (06), 205–207.
[13] Yingying Zhou, Tao Yang, Web3D technology and its application, *Journal of Luohe Vocational and Technical College* 2019,18(05), 38–40.
[14] Khronos Group, Web3D , virtual reality modeling language，international standard, *ISO/IEC 14772* 1997, 5.
[15] Mingjie Bian, Jue Gao, Honghao Gao, Jiepin Xu, Research and application of Web3D visualization technology, *Computer Technology and Development* 2015,25(06), 141–144.
[16] Yingqiong Bu, Research on product display technology based on VRML and Web, *Jiangnan University* 2005.

[17] Ruchuan Wang, Xumin Yao, Haiyan Wang, Li Liu, Research on the communication method of virtual scenes based on Java and VRML, *Journal of Systems Simulation* 2003(07), 986–990.
[18] Xu Yang, Rongzhi Wang, Shuang Li, Research on the application of Cult3D technology in the development of web-based virtual experiments, *Experimental Technology and Management* 2007(01), 83–86.
[19] Chunyu Wang, Guangwen Zhang, Cult3D technology and its application in the display of ceramic products, *Chinese Ceramics* 2007(01), 49–51.
[20] Yuesheng Wu, Introduction to the application of 360° panoramic photography technology in the digital virtual museum, *Xiamen Technology* 2014(06), 24–27.
[21] Juan Wang, Jun Shi, Xianxiang Wu, Overview of image stitching technology, *Computer Application Research* 2008(07).
[22] Xiaoyou Huo, Zhongyuan Meng, Qi Yang, Virtual Reality - Digital Preservation and Display of Terracotta Warriors Sites and Artifacts in Qin, *Southeast Culture* 2009(04), 98–102.
[23] Tong Wang, Liang Wang, Nan Ma, Research and application of virtual reality technology based on panoramic map in digital museum, *Shanxi Electronics Technology* 2011(01).
[24] Qinping Zhao, Virtual Reality Overview[J], *China Science* 2009,39(01), 2–46.
[25] Yue Yin, Immersive study of panoramic news in new media, *East China University of Political Science and Law* 2021.
[26] Kim, S., Lee H, Visitor Attention and Communication in Information-Based Exhibitions, *International Journal of Design [Online]* 10:2,2016.
[27] Xiaocheng Yin, Guandong Sun, Zhaopeng Zhang, Yuqi Liu, Application of card-based web design in shopping websites, *Art and Design (Theory)* 2016,2(06), 66–68.
[28] Haywood N, Cairns P, Engagement with an Interactive Museum Exhibit, *People and Computers XIX — The Bigger Picture* 2006.
[29] Mafkereseb Kassahun Bekele, Roberto Pierdicca, Emanuele Frontoni, Eva Savina Malinverni, James Gain, A Survey of Augmented, Virtual, and Mixed Reality for Cultural Heritage, *J. Comput. Cult. Herit* 2018.
[30] Li J, Nie J-W, Ye J, Cairns P, Evaluation of virtual tour in an online museum: Exhibition of Architecture of the Forbidden City, *PLoS ONE* 17(1).
[31] Qiulian Zhang, Han Li, Exploring the application of 360-degree panoramic display in virtual museum, *Journal of the National Museum of China* 2011(09),154–156.
[32] Wojciechowski R, Cellary W, Ye J, Cairns P, Evaluation of learners' attitude toward learning in ARIES augmented reality environments, *Computers & Education* 68, 570–585.