Investigation on Circumstance Art Design Method Based on Edge Computing and Interactive Virtual Simulation

Jiabai Jin[1,a], Jiaji Zhou[1,b,*]

[1]*College of Art and Design, Changchun Humanities and Sciences College, Changchun, Jilin, 130000, China*
[a]*18243587777@163.com,* [b]*zhoujiaji1@ccrw.edu.cn*
[*]*Corresponding author*

Abstract: In the new era, virtual simulation technology has made great contributions to education, medical treatment, entertainment, etc. With the development of the economy, the progress of society and the improvement of people's living standards, simulation technology has begun to affect the lifestyle and entertainment of modern people. It is also a new change for today's art and design work. In previous design work, designers often decide the design content by observing models and field trips. This is very one-sided, and the cost of time and manpower is also high. Therefore, the Virtual Reality (VR) technology that breaks through the traditional means of expression, static renderings and spectator models undoubtedly brings new opportunities to the reform of previous design work. However, the society is constantly developing, and the current production and life of virtual reality technology has put forward higher requirements. The virtual simulation technology based on cloud computing server relies heavily on the cloud data center, and the privacy and security cannot be guaranteed. Data redundancy, long computing time and high deployment costs have been criticized, and the current economic production requirements and life needs incompatible. Based on the above reasons, it can be seen that it is necessary to apply Edge Computing (EC) and Interactive Virtual Simulation (IVS) technology to circumstance art design. Compared with the traditional virtual technology based on cloud computing server, EC and IVS technology have huge advantages. EC and IVS technology adopt distributed computing, and are able to analyze, process and organize useful information in the first time. Data processing time is short, and EC only transmits and processes useful information. The operation efficiency was higher than that of cloud computing, reaching 33.2%. The cost was less than that of cloud computing virtual technology deployment, with an average of 38.9%. Privacy and security were relatively guaranteed. By comparing the three design methods mentioned above, through the relevant experimental data and practical experience, it could intuitively show the incomparable advantages of the design method based on edge computing and interactive virtual simulation technology and the inevitable trend of its wide application.

1. Introduction

Virtual technology has made a very important contribution in various industries and has become an important way to promote technology upgrading in related industries. This is particularly prominent in the circumstance art design work. Due to the complexity of the form of circumstance design, it is necessary to use virtual reality technology in circumstance design. Through the comparison between EC and past virtual reality technology, the advantages of EC technology are highlighted [1]. Through the collection and collation of many relevant usage and experimental data, the possibility and necessity of applying EC and IVS technology in circumstance art design are evaluated. New solutions and development directions are proposed for the reform of traditional circumstance art design methods. In the actual operation process, relevant personnel are often required to make overall plans and pay attention to details. When using EC technology in circumstance art design work, attention should be paid to the particularity of the circumstance and the accuracy of the collected data. In the design process, measures should be adjusted to local conditions. When designing works, designers should consider the feelings of customers. Through relevant experiments and data, the advantages and characteristics of EC in the field of circumstance art design work are truly reflected [2].

2. Development of VR Technology and the Possibility of Its Application in circumstance Art Design

(1) Concept of cloud computing virtual simulation technology and EC based and IVS technology

The Internet has been developing since 1960. At first, it was mainly used in the military and large enterprises, and it did not enter ordinary families until 1990. With the development of economy and the progress of science and technology, the network has become one of the necessities that people cannot live without [3].

Cloud computing appeared relatively late compared with the Internet, but it has developed rapidly. Today, cloud computing has become the strategic focus of the development of the information technology industry, and the global information technology enterprises are all transitioning to cloud computing [4].

What are the specific concepts and definitions of cloud computing? Although the development of cloud computing technology is quite perfect and has gone deep into all walks of life, its definition is relatively broad. Cloud computing is roughly classified into three categories according to the deployment model: public cloud, private cloud, and hybrid cloud; if classified according to the service model, it can be divided into Software as a Service (SaaS), Platform as a Service (PaaS) and Infrastructure as a Service (IaaS).

The so-called EC can be understood as "the nearest cloud computing". However, from many consensus points of view, EC does not belong to cloud computing, and it is a supplement or pretreatment of cloud computing (as shown in Figure 1).
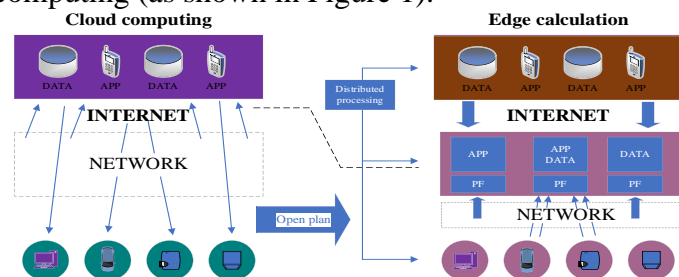

Figure 1: Cloud and EC concepts

EC is a new computing method for implementing distributed computing. Its core idea is to connect, compute, store and apply core capabilities of the distributed open platform in the place closest to the mobile terminal through the integration of network. In brief, EC is to analyze and calculate the data collected from the terminal directly in the local device or network close to the data generation, without transmitting the data to the cloud processing center. Pan Jianli summarized and described EC as follows: It was a new computing model that deployed computing and storage resources (such as cloudlets, micro data centers or fog nodes) on the network edge near mobile devices or sensors. What can EC do? Deng Shuiguang learned from research that EC mainly served the Internet of Things (LOT). The following devices can be networked, such as intelligent wearable terminals, intelligent machine tools, intelligent furniture appliances, unmanned aerial vehicles, intelligent driving cars, intelligent ports, etc. These various devices form a huge communication system through sensors or preset programs. In order to maintain the normal operation of the system and deal with problems like people, a large amount of data needs to be calculated and fed back in time. Nowadays, cloud computing has exposed many drawbacks when it is used for a large number of data processing [5].

(2) Advantages of cloud based virtual technology compared with EC and IVS technology

As mentioned earlier, both cloud computing VR technology and EC interactive VR technology serve the Internet of Things. However, as a complex and huge system, the Internet of Things has different application scenarios in different industries. According to the statistics of third-party analysis institutions, in another 5-10 years, the amount of terminal data in the whole network would reach 300ZB, and the average person would generate 1.5GB of data every day. The real-time processing of massive data may make cloud computing inadequate, and cloud computing with the central server as the node may encounter a broadband bottleneck. In some individuals, departments or enterprises with high requirements for data privacy and security, traditional cloud computing processing needs to transfer data to the cloud. Long distance transmission of data brings great security risks to the privacy and security of data. For the above problems of cloud computing virtual technology, the virtual simulation technology based on EC and interactivity shows reasonable aspects [6].

EC is the future trend of VR technology. Although it is still in its infancy, it is developing rapidly. At present, the development is slow due to technical reasons. However, with the progress of science and technology and the popularization of the corresponding 5G technology, EC has broad prospects and is the trend of VR technology. Compared with cloud computing, EC has the following advantages, as shown in Table 1.

Table 1: Advantages of cloud computing versus EC

Project	Cloud Computing	Edge calculation
Method of calculation	Centralized computing, relying on cloud data centers	Distributed computing, focusing on real-time, short-cycle data analysis
Time delay property	High delay time	Low delay time
Cost of deployment	High	Low
Position of processing	Cloud data center	Close to the terminal device or IOT switch that generates data
Data storage	All the information collected	Only useful processing information is transmitted to the remote end without redundant information
Privacy Security	Privacy and security are relatively low, requiring high attention	High privacy and security

Advantage 1: fast processing speed and high working efficiency.

Compared with cloud computing, EC has four types of computing nodes: terminal nodes (It is composed of various intelligent terminals, which mainly complete the function of collecting raw data and reporting. In the terminal layer, it only needs to provide the sensing capabilities of various access devices, but does not need separate computing capabilities.); EC node (It realizes the corresponding basic services by reasonably deploying and allocating the computing and storage capacity of the nodes at the edge of the network.); cloud computing nodes (It receives and stores the collected and processed useful information.); network node (It is responsible for uploading useful data processed by EC to cloud computing nodes for analysis and processing.).

Advantage 2: closer to the terminal equipment, more secure transmission, and more timely data processing.

Under the technical framework of EC, data generated by intelligent terminal devices of the Internet of Things does not need to be transmitted to remote cloud data centers for processing. It follows the principle of proximity and completes data analysis and processing at the edge of the network. Compared with cloud computing, the response time is very short. The running speed is very fast, and it is more secure.

Advantage 3: More decentralized nodes have less impact than cloud computing failures, and also solve the problem of device cooling.

More decentralized nodes can process multiple data at the same time. The failure of a single node does not affect the analysis and processing of data by other nodes. Therefore, compared with cloud computing, the probability of failure is very low. In addition, multiple nodes are distributed to process data to avoid excessive server pressure when there is too much data, resulting in delayed data processing and equipment heating.

(3) Feasibility of EC and IVS technology in the field of circumstance art

The traditional method of circumstance art design has great drawbacks. In the early stage of design, traditional circumstance art design methods often require designers to draw sketches by hand, including plans, perspective renderings, sections and elevations, ceiling plans, and three digit models. This is not only a great test of designers' spatial imagination, but also a waste of manpower. After investigating the terrain and determining the materials, it is necessary to design the construction drawings to facilitate the communication between designers and constructors, which also causes a waste of human resources. If the scheme is changed later, the impact on the construction progress of the whole project would be very serious, resulting in project delay and cost improvement. The traditional circumstance art design process is shown in Figure 2.

In the field of circumstance art design, there would be many advantages if EC and IVS technology are combined with traditional circumstance art design methods.

Advantage 1: efficiency

Based on EC and IVS technology, it is of great significance to improve the work efficiency of circumstance art designers, which not only saves human costs, but also improves the quality of works. After using the environment design method based on EC and IVS technology, various scenes can be simulated, and the design scheme can also be viewed and changed anytime and anywhere, including terrain, material selection, scheme change, art style change, etc., which improves the work efficiency in a formless way.

Advantage 2: interactivity

The works designed by circumstance art design based on EC and IVS technology can be fully displayed, and the scene can be panoramic simulated at any time and place. From a small house to a distant universe, they can be presented to the world in a digital form through VR technology. This allows customers to feel immersive, and they can immediately feel and receive the status and information after the completion of the work. The panoramic simulation effect picture presented by VR technology has a special artistic charm. In this way, designers can change the design style at

will to find the most appropriate scheme. At the same time, it can also foresee and warn about safety problems. This technology is a new breakthrough in the traditional circumstance art design method, which has brought circumstance art design to a new height.
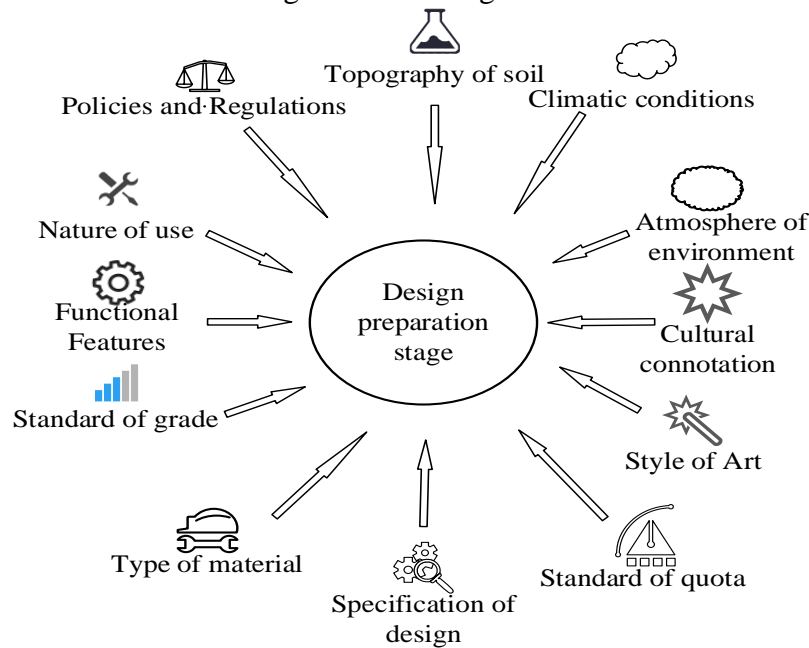

Figure 2: Flow chart of traditional circumstance art design method

Advantage 3: intuitive

With the development of economy and the acceleration of urbanization, the traditional circumstance art design can no longer meet the needs of development, and the reform of traditional circumstance art design is imminent. When using the circumstance art design scheme based on EC and IVS, compared with the traditional design method, the new technology is more in line with the production and life needs in terms of visual expression. The new circumstance art design method can more intuitively show the overall content and details of the design scheme by establishing a panoramic 3D model. With the advantages of new technology, people can be immersive and fully understand the content of the design scheme. Therefore, the circumstance art design method based on EC and IVS technology is more intuitive than the traditional art design method.

Advantage 4: artistic

By using VR technology to redesign circumstance art, many problems need to be paid attention to. For example, the quality of finished products should be emphasized. When rendering 3D models, attention should be paid to clarity, accuracy and other issues. Through the circumstance art design method based on EC and IVS technology, clear pictures and relevant geographical environment information can be obtained through high-definition shooting equipment. Based on this information, a very clear and accurate 3D model panorama can be drawn. In the 3D panorama simulation diagram, the content and artistic characteristics of the whole project can be clearly understood, which is not available in the traditional circumstance art design method. Therefore, the new method of circumstance art design based on EC and IVS is more artistic in design content.

Advantage 5: multi perception

VR technology has made rapid development in the past decade. Although in other industries, the concentration of VR has been perfect, there is no corresponding specification and requirements for the application of VR technology in the field of circumstance art design. Therefore, many problems are easy to occur in the specific design work. The circumstance art design method based on EC and IVS technology can give people a sense of immersive experience through 3D panoramic models,

and can fully experience the artistic charm of works.

Advantage 6: security

Traditional circumstance art design is limited by various practical conditions, and there are many dangerous situations in actual operation, which virtually increases the cost of time and manpower. After the use of EC based and IVS technology, relevant personnel can have a preliminary understanding of the overall project through the three-dimensional panoramic simulation diagram, which can reduce or avoid accidents during the project.

(4) Specific usage of circumstance art design method based on EC and IVS technology

1) Construction process of 3D panoramic model

The 3D panoramic simulation of the environment is simulated and constructed using Google's Sketch Up platform. With the help of this software, the collected information is processed and sorted out to create a 3D panoramic model. The detailed process is shown in Figure 3:
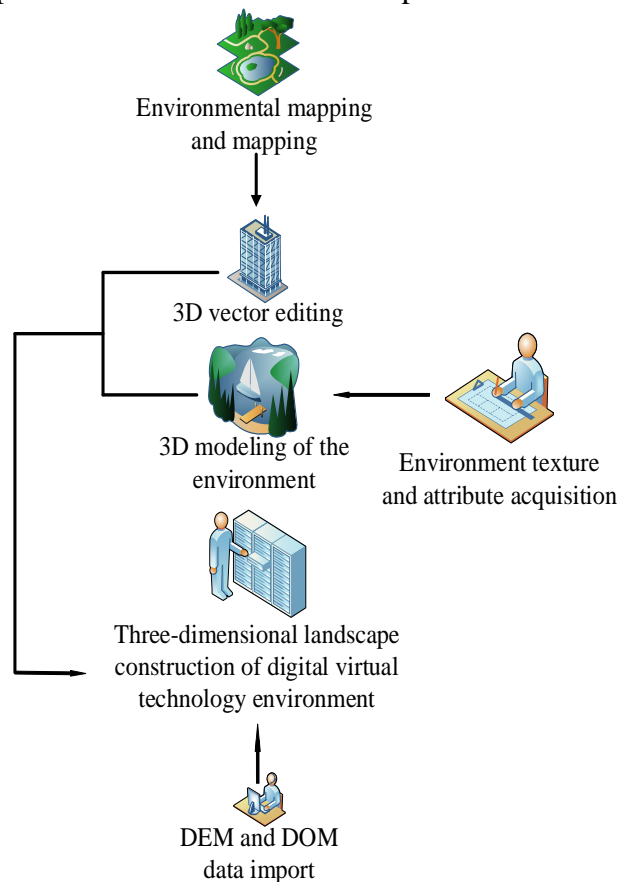

Figure 3: Flow chart of 3D panorama model creation

2) Editing of 2D vector graph

For the processing of the collected images, other irrelevant layers should be deleted, and the relevant geographic environment information such as rivers, vegetation, roads, etc. needed to build a 3D panoramic simulation should be retained. In order to improve the authenticity of the simulation environment and obtain a more intuitive experience, it is necessary to ensure that the 3D modeling software on the Google platform mentioned above removes clutter and linearity to ensure normal operation. When sorting out and analyzing the massive circumstance information such as lakes, lawns and roads, it should be noted that the collected images are in a closed loop state, and the intersection of corner lines should also be noted.

3) Collection of environment texture attributes and other geographic data information

On site, professional equipment photography is used to collect relevant picture information, which can build a more realistic 3D panoramic model. According to the collected relevant picture information, the texture information and other relevant data of the virtual environment can be obtained, and the acquired scene picture information can be processed from an angle. In order to make the acquired data more complete and real, small angle shooting is used in the process of acquiring picture information. By sorting and analyzing the data, the required image texture and other geographic information can be obtained.

4) Preliminary establishment of 3D panoramic model

In order to make the 3D panorama model built closer to the real design content, further processing is required for the built model. There are two processing methods: One is to use PS software to texture map the collected image information; the other is to use some image information for texture mapping, and the rest is to use Google platform 3D simulation software to process textures and materials. Compared with the first method, the second method is more convenient and faster to operate, and the final effect is better. The panorama model built by the second method would be more realistic. Therefore, the current mainstream direction is to use the second method.

5) Construction of 3D panoramic model

The collected picture information is sorted out and embedded into the image and terrain layers using the 3D simulation software of Google platform. After data analysis and processing, the preliminarily established 3D model and the 3D model provided by Sketchup platform are embedded into each other. After saving, they are embedded into Sketchup platform again. According to the collected pictures and geographic information, the specific location points of the 3D panoramic model are determined. After the 3D panorama model is established, it can be viewed on Google Earth platform.

6) Circumstance art design method creation based on EC and IVS

When carrying out circumstance art design based on the 3D panorama model, it is necessary to reform and innovate the traditional circumstance art design from the physical aspect of reality and the subjective aesthetic aspect of customers, as shown in Figure 4:
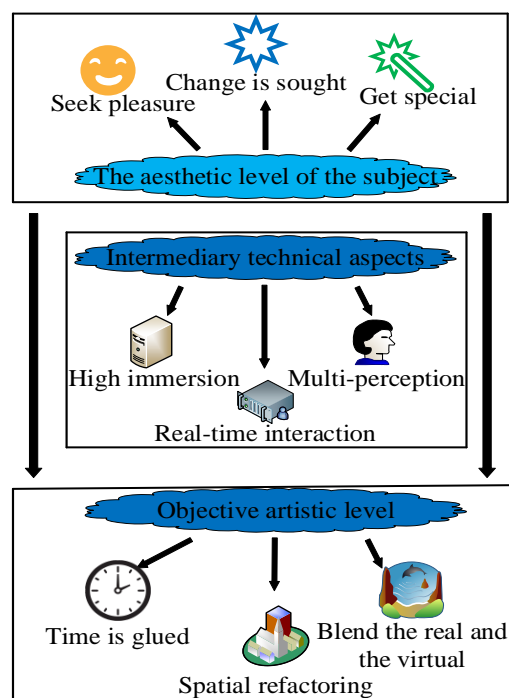

Figure 4: The chart of reform and innovation

3. Experimental Evaluation Designed with EC and IVS Technology

A modernist park was built in a certain area, which covered an area of 52.2×10^4 m². The total cost was 2.5 million yuan.

In order to highlight the advantages of EC and IVS technology in the field of circumstance art design, Geographic Information System (GIS) was used to build 3D models and digital photography 3D modeling methods were used in the planning process. Two 3D modeling methods were compared to obtain the 3D modeling accuracy of these two methods, which was then compared with the new method adopted. The specific data is shown in Figure 5:
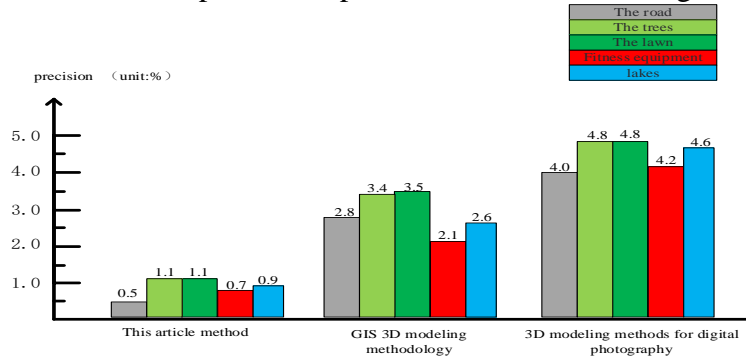

Figure 5: Comparison of experimental data in three ways

From the comparison data of error results in Figure 5, it could be seen that the error between the rendered 3D model and the actual one in the circumstance art design based on EC and IVS technology was less than 1.1%. The error of GIS 3D modeling method was 2.1%-3.5%, and the error of digital photography 3D modeling was higher than 4.0%. From the experimental data, it could be concluded that the 3D modeling based on EC and IVS technology had the smallest error and the highest accuracy in the actual environment design, so it was more suitable for circumstance art design.

Table 2: Comparison of efficiency parameters of the three models (unit: %)

Methods	Form of landscape	Degree of fidelity	Increase efficiency	Cost reduction
New method of this paper	Fitness equipment	91	36	38.6
	lakes	94	33	39.2
	The trees	96	30	40.3
	The road	94	34	41.5
	The lawn	94	33	34.9
GIS 3D modeling method	Fitness equipment	88	20	18.6
	lakes	80	19	17.2
	The trees	86	17	20.5
	The road	89	12	20.1
	The lawn	85	19	19.3
Digital photography modeling methods	Fitness equipment	81	12	20.1
	lakes	86	20	20.6
	The trees	83	16	19.3
	The road	81	18	20.6
	The lawn	80	19	19.6

The use of EC based and IVS technology in the planning and design of the park took a total of 40 days, and the design cost was 110000 yuan. In order to verify the advantages of the circumstance art design method based on EC and IVS, the relevant actual data are shown in Table 2.

It could be seen from the data in Table 2 that the fidelity of the park designed based on EC and IVS technology reached 93.8%; in terms of efficiency improvement, the average value of the new method based on EC and IVS technology was higher than the other two methods, reaching 33.2%; in terms of design cost, compared with the other two methods, the average cost of the new text method was 38.9%. The other two methods had no obvious advantages in terms of fidelity, efficiency and cost. EC and IVS technology were superior to the other two methods in all aspects of circumstance art design.

4. Discussion

From the relevant data obtained from the above actual projects, it could be concluded that circumstance art design based on EC and IVS technology had three advantages over traditional circumstance art design.

(1) More realistic and accurate design scheme

Virtual simulation technology based on EC collected and processed data at the latest network edge. Therefore, compared with traditional VR technology, EC virtual simulation technology had the characteristics of fast transmission speed, real-time processing, etc. This did not require cloud computing to transmit data to the cloud computing server, and the privacy and security of data were also greatly guaranteed. Therefore, based on these advantages, EC could quickly collect and process large amounts of data in circumstance art design, and the 3D panoramic model renderings were more realistic and closer to the real scene.

(2) Higher efficiency

It could be seen from the experimental data that the efficiency of the circumstance art design method based on EC and IVS technology was greatly improved compared with the previous circumstance art design methods both in the design process and in the later work. The average improvement efficiency was 33.2%, which was mainly due to the huge advantages of EC based and IVS technology itself over traditional circumstance art methods.

(3) Lower cost

From the above contents and experimental data, it could be seen that the circumstance art design method based on EC and IVS technology was more conducive to the specific implementation of the design scheme and the reform of the subsequent design content, including changing the design style, replacing the design materials, etc. Therefore, the new method was more conducive to reducing costs. At the same time, it could also predict and prevent some safety accidents, which was not available in traditional circumstance art design methods.

After understanding the disadvantages of traditional circumstance art design, a new circumstance art design method was adopted to build a 3D panoramic model, which made the designed products more intuitive to watch. This was a major breakthrough in traditional circumstance art design methods. In the experimental comparison, this paper compared the design scheme using the new method with the traditional circumstance design scheme, and intuitively showed the advantages of the new method and the future development trend of the circumstance art design field through the data obtained. However, it should also be noted that both the traditional circumstance art design method and the newly proposed circumstance art design method based on EC and IVS technology should take into account the principle that people should be the center and should live in harmony with nature. This was the significance of circumstance design.

5. Conclusions

The circumstance art design method based on EC and IVS technology could enhance the authenticity of design works and give people a sense of immersive. This made people feel as if they were in it and appreciate the spiritual shock brought by circumstance art design. At the same time, it also enhanced the safety of the entire design project, and radiated new vitality in the field of circumstance art design, which was a major breakthrough in the field of circumstance art design. The emergence of new technology made circumstance art design break through the time and place constraints, which was more in line with customer needs. However, it should also be noted that the current virtual simulation technology based on EC and interactivity was still in the early stage of development, and there were still many areas to be improved. As a circumstance art designer, the people-oriented concept should be adhered to when using new methods to design.

References

[1] Bashabsheh, Ahmad K., Hussain H. Alzoubi, and Mostafa Z. Ali. "The application of virtual reality technology in architectural pedagogy for building constructions." Alexandria Engineering Journal 58.2 (2019): 713-723.

[2] Xue, Chunyan. "Research on the expression of circumstance art design based on virtual technology." Revista de la Facultad de Ingenieria 32.9 (2017): 560-565.

[3] Zhanjun, Wang "Application research of virtual reality technology in circumstance art design." Acta Technica CSAV (Ceskoslovensk Akademie Ved) 62.1 (2017): 215-224.

[4] Wang, Xiaofei,"In-edge ai: Intelligentizing mobile edge computing, caching and communication by federated learning." IEEE Network 33.5 (2019): 156-165.

[5] Zhou, Zhi,"Edge intelligence: Paving the last mile of artificial intelligence with edge computing." Proceedings of the IEEE 107.8 (2019): 1738-1762.

[6] Chin, Kai-Yi, Ching-Sheng Wang, and Yen-Lin Chen. "Effects of an augmented reality-based mobile system on students' learning achievements and motivation for a liberal arts course." Interactive Learning Environments 27.7 (2019): 927-941.