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Immersive ERP Experiment Based on 3D-Reconstruction Model of Panoramic Images

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Abstract. This study extends the application field of VR technology, and studies on the physical image problem of inventory management in ERP immersive experiment under VR technology, using the SSD block matching algorithm and the panoramic image in-depth information extraction algorithm to extract the two-dimensional in-depth information in the panoramic images. Then we reconstructed the object in 3D. The results show that the image reconstructed in 3D is clearer, more stereoscopic, and interactive, which solve the problems of low resolution, distortion, and low interaction in ERP virtual teaching environment, while using multimedia and camera roaming to enhance students' immersive experience, achieve high-precision, real scene, better virtual teaching environment interaction. It can be seen that the immersive ERP experiment based on VR technology is conducive to improving students 'professional ability and docking ability, as well as improving students' overall cognitive ability and operation ability of the ERP system.

Keywords. Panoramic image, 3D-reconstruction, SSD block matching Algorithm, VR, ERP

1. Introduction

In May 2021, China issued the Notice on the Pilot Work of Technology and Standard Innovation Demonstration Projects in the Publishing Industry. It focuses on the innovative research in the publishing field of new technologies such as big data, artificial intelligence, block-chain, cloud computing, the Internet of Things, virtual reality and augmented reality [1]. Augmented reality (AR), virtual reality (VR) and other technologies are generally called extended reality (XR), which refers to a technology that combines real and virtual reality through computers to create a virtual environment for human-computer interaction. In recent years, with the iterative update of VR technology products, VR technology has gradually played an important role in entertainment, production and other fields. VR technology has gradually entered the education and vocational training of primary and secondary schools, universities and enterprises. Studies by Zahira Merchant, Tassos A Mikropoulos, and others reviewed the VR design

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in higher education and showed that people have an interest in using immersive VR techniques in many different fields [2]. A review of immersive VR application systems in higher education identifies engineering, computer science, and astronomy as the most popular applications. Other categories such as biology, geography, art, and chemistry are also applied areas of higher education. VR application teaching can enable students, teachers and users to devote themselves to a realistic environment of virtual learning through creation of situation. Meanwhile, the low-latency and high-broadband features of 5G technology provide the practicability for the interactive scenes applied to VR devices [3].

2. Current status of ERP immersive experiments

At present, the "China 5G + VR" webcast held by Huazhong University of Science and Technology, through the connection of "free of dead corner" teaching scene, teachers, system of knowledge, technical links and other aspects, makes the student learn mode changes. Guangxi University of Finance and Economics has built a holographic XR virtual training base, combining theory and practice, so students can fully master engineering professional knowledge. Beijing Normal University applies AR technology based on "VR / AR + education" laboratory research, hence students can easily conduct experiments which requirements are relatively high in mathematics, physics, chemistry, science and other subjects. VR technology has certain applications in many aspects of the education field. [4]

VR technology has become an auxiliary tool for education, which can simulate the real situation of the content of subject learning. By engaging students in the real situation for operation, it can reduce the experience cost and study cost of the subjects and guide students to carry out deep learning. [5]

Enterprise Resource Planning (ERP) was proposed by Gartner Group Company in 1990 and refers to the management platform based on information technology and providing enterprise decision-making levels and employees with systematic management ideas. However, the application of VR technology in ERP experiments is not common, and the ERP teaching in higher education generally uses the traditional teaching methods. That is, through the ERP sand table simulation for a simulation enterprise, the key links of the enterprise operation system and other operation mode are designed as the main content, showing the operation and management process of the enterprise in an all-round way. This experiential teaching method integrates teaching theory and practice, role playing and post experience, also provides better help in expanding students system of knowledge, establishing win-win concept and overall concept, and training students' enterprise business ideas.

Although higher education has already applied an experiential teaching method, students still have more needs in ERP experiments. The application of VR technology in the ERP experiment is a revolutionary teaching method. Our study is to apply the VR technology of panoramic image, 3D-reconstruction and other algorithm technologies, adding an immersive experience in the ERP teaching, to create a virtual and interactive ERP learning environment [6]. In the virtual environment, students can truly experience the content and process of professional work [7]. No longer limited to slice, single knowledge, students can access to the diversified content. Contrast with the universal traditional teaching mode, it can improve students' learning autonomy and solve the problem that it is difficult for students to experience the real environment and process of working [8]. With reasonable architecture design and equipment support, "VR + ERP" is feasible.

3. 3D-reconstruction model based on panoramic images

3.1. VR technology

Virtual Reality (VR) is a technology to realize the combination of virtual and reality, and to build a virtual environment with a computer simulation system. It involves computer graphics, stereoscopic display technology, tracking technology of user interaction site and other subject fields. It was first proposed in Ivan Sutherland paper called "The ultimate display" published in 1965 in US. Then, a helmet display device and a head and hand tracker were successfully studied. Immersion, interactivity and conception are the three basic characteristics of VR technology [9]. At the same time, VR system has four different categories, they are mainly divided into immersive categories, non-immersive categories, distributed categories and augmented reality. This study focuses on the application of immersive VR systems in ERP experiments.

3.2. 3D-reconstruction model of panoramic images

The application of VR technology can improve the operability of students in ERP simulation experiments, and 3D-reconstruction can provide more considerable help for the implementation of ERP immersive experiments under VR technology. The 3D-reconstruction of VR panoramic image takes the panoramic image technology as the entry point, which has the advantages of relatively simple recording process, low support cost of related equipment, and can be applied to static and dynamic three-dimension scene capture, convenient to use and so on. We obtain the in-depth information on the distance between the pixel point and the camera by converting two-dimensional plane images into pixel coordinates in three-dimensional space and calculating the disparity. The panoramic image of the VR room can be constructed in three-dimension, so as to obtain a higher resolution and more realistic virtual teaching interaction environment.

The neighborhood restriction and relaxation methods to deeply extract the panoramic images, and fitted the expected value in a composition to determine the best disparity value, hence realized the 3D-reconstruction of the specific panoramic images

The basic steps of the algorithm are as follows.

For panoramic images, microlens arrays are usually used to display three-dimensional scenes. The in-depth information of the three-dimensional object is also recorded. Here we note D as the required in-depth information, d as the disparity of the selected views of two, Ψ as the aperture of the microlens array subunit, and F as the focal length of the microlens array subunit, Δs as the "baseline", representing the sampling distance of the two selected views ($\Delta s = ds_1 - ds_2$).

$$D = \frac{(d \pm 1) \cdot \Psi \cdot F}{\Delta s} - d_r \qquad (1)$$

Where, F, d_r, Ψ are the parameter, in most cases, $d_r d_r \ll D$, so that the range of error and the range variation of d are not considered here. Simplify the formula to:

$$D = \frac{d \cdot \Psi \cdot F}{\Delta s} \qquad (2)$$

Formula (2) indicates that the in-depth information of a panoramic image can be obtained through the disparity information and the parameters given a microlens array. In order to further obtain the in-depth information of panoramic images, the common matching algorithm is generally used to calculate. Here, a block matching algorithm based on the SSD calculation criteria is used to deeply extract the VR panoramic images.

Sum of Squared Differences is the SSD algorithm for short. That is, compute L2 distance between the sub-graph and template. Its formula is:

$$D(i, j) = \sum_{s=1}^{M} \sum_{t=1}^{N} [S(i+s-1, j+t-1) - T(s, t)]^2 \tag{3}$$

This algorithm can perform image template matching by code running.

Block matching algorithm is a general term for computer algorithms used to find the same or similar image blocks as a given image block in a special image. It is based on the multi-window matching algorithm of Neighborhood Constraint and Relaxation. This algorithm can default that the in-depth space is continuous and segmented. The basic steps of the algorithm are as follows.

After shooting the same panoramic image at different angles, take the two views as P_1 and P_2 respectively, note that there are pixels (x, y)in P_1that matches P_2, and get the region of P_2 from (x, y) that best matches P_1, noting as $(x+d, y)$, $d \in [-R, R]$.

The expected disparity value of block matching algorithm as obtained when taking the minimum value, that is:

$$d^* = \arg\left\{\min_{d \in R} \left\{\sum_{x, y \in \omega} [P_1(x, y) - P_2(x+d, y)]^2\right\}\right\} \tag{4}$$

In the formula (4), $(x, y)$is the pixel recording point coordinates. $P_1(x, y)$is the intensity of the pixel recording point(x, y), ω is the matching window to be specified, and R is the image pixel matching interval.

when we use multi-window matching algorithm of neighborhood restriction and relaxation , there is a sub-window $B_{i,j}$ of pixels (i, j) and a neighborhood sub-window $B_{k,l}$ of pixels (i, j) . When conducting the analysis of the sub-window disparity d, we can consider its neighborhood sub-window together to obtain more effective results.

At this time, after considering the neighborhood relaxation, improving the neighborhood block and matching block determination criteria [6], it can be concluded that:

$$\mathrm{score}(B_{i,j}, d) = \mathrm{SSD}(B_{i,j}, d) + \sum_{B_{k,l} \in N(B_{i,j})} \omega(B_{k,l}, B_{i,j}) \mathrm{SSD}(B_{i,j}, d) \tag{5}$$

Here, $B_{i,j}$ is a sub-window of pixels(i, j), and $B_{k,l}$ is $B_{i,j}$ a neighborhood sub-window. $\omega(B_{k,l}, B_{i,j})$ is the weight factor of the corresponding different neighborhood blocks, and $N(B_{i,j})$is the neighborhood set of the matching blocks.

There is disparity between different neighborhood blocks, so different disparities will have different local presentation. Because the neighborhood blocks are different from the matching blocks. A variable is added to calculating SSD:

$$\mathrm{SSD}(d) = \sum_{x, y \in \omega} [P_1(x, y) - P_2(x+d, y)]^2 \tag{6}$$

Thus, when calculation, the neighborhood constraint is determined by the window SSD and the variable when the neighborhood is relaxed. Based on the subject, the minimum function score is the expected disparity value. However, there will be a residual value after calculating with the SSD standard, so we define a threshold value R_{bp} that is θ times of the minimum residual value, there are:

$$R_{bp} = \theta \cdot min\_residue \qquad (7)$$

In the process of evaluating, we end up taking all values that are less than the threshold.

When values such as d_1, d_2, d_3 and so on are obtained by the score function are all less than the value R_{bp}, in order to find the most accurate expected value, we use that quadratic formula of a parabola that passes through the values d_1, d_2, d_3 and so on. At this time, the expected most accurate disparity value of the parabola is taken at the lowest point of the parabola, according to the definition of a parabola.

Panoramic image records the three-dimension spatial information in the form of two dimensions. That is, we can use above algorithm to extract the in-depth information in the two-dimensional view, applying the in-depth information to the 3D-reconstruction, so as to improve the resolution and reconstruction accuracy of the panoramic image. It can effectively solve the distortion problem of the traditional 3D-reconstruction.

3.3. Camera roaming and multimedia access

Enhance immersive experiment experience refers to the scene can get visual effect, into the camera roaming can let the users in the process of interaction with virtual environment more deeply feel the object and environment distance and line of sight change. With the movement of the object drove by the movement of the eyes, the specific content of the environment gets into the brain, as the eyes of the world in reality. Internet platforms can be used to find roaming interactions mode with specific VR devices. The ERP immersive environment mentioned in this article uses a hand sensing instrument to move up, down, right and around the line of sight through the rotation of the helmet.

Multimedia substitution refers to the import of the corresponding data markers in the ERP sand table simulation, which constructs the required animation (such as inventory object animation) through 3DSMax and other software, load the corresponding database of the VR device in the form of FBX, and then set the next step when using the VR device.

3.4. Solve the problem of scene and image of inventory management in immersive ERP experiment

After taking panoramic images of three-dimension objects in ERP experiments, such as warehousing-specific inventory items, the disparity values between different views are calculated according to the block matching algorithm. After extracting the in-depth information based on the given microlens array parameter, 3D-reconstruction can effectively improve the accuracy of inventory physical models in immersive ERP experiments. If the finished product mentioned in the purchase plan is physically photographed, we use the SSD block matching algorithm to the different two-dimension plane views obtained. Then we use the score function to find the most accurate disparity value d for different views, and use formula D of the in-depth information extraction to obtain the in-depth information for 3D-reconstruction.

The reconstructed panoramic images are applied to the VR image library, when students make inventory in and out in the ERP experiment through VR equipment, the modeling accuracy of the simulated items would be quite high. Its high resolution and high precision stereoscopic-state when students touch the inventory items will give students a better simulation experience. That is, not only does the virtual scene in the ERP experiment become more realistic, interaction will also be higher when counting items. Thus the problem of inventory management image when students use technology to experience ERP experiment in an immersive way will be better improved, and further strengthen the students' practical operation ability in this aspect of the ERP experiment. The solution process is shown as Figure 1.

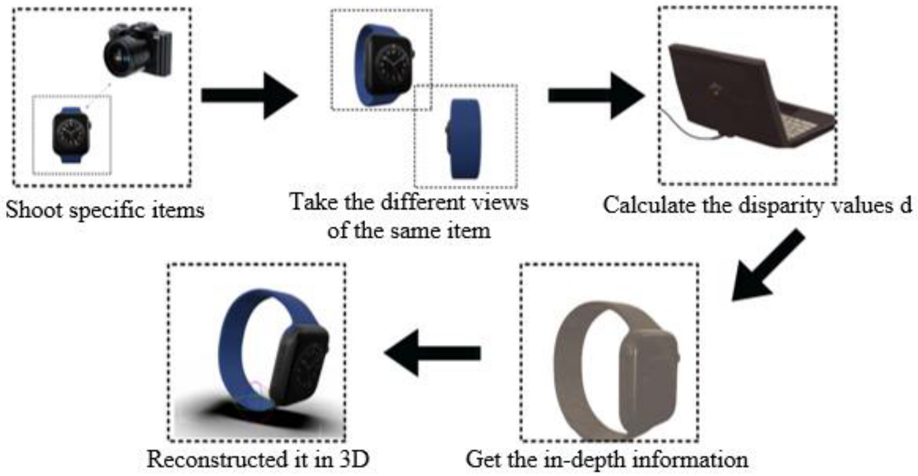

Figure 1. Solution process

(1) The first step is to shoot specific items.

(2) The second step is to take the different views of the same item.

(3) Thirdly, the SSD block matching algorithm is used to calculate the disparity values d for two view-specific windows.

(4) At a given microlens array parameter, the disparity value d is replaced into the panoramic image in-depth information extraction formula D to obtain the in-depth information of the two-dimensional panoramic image.

(5) The in-depth information of the obtained panoramic image is reconstructed in 3 D and applied into the VR image library.

Through the above steps, it can improve the fidelity and interactivity of the immersive ERP warehousing management experiments under the VR technology and realize the high accuracy of item model.

4. Experimental results

This study used the SSD block matching algorithm and panoramic image in-depth information extraction algorithm to get the two-dimension in-depth information of panoramic image, and reconstructed it in three-dimension. We took photos for items of the assumed inventory management included in the ERP experiment, after taking different views by using the algorithm evaluation, we reconstructed two-dimension panoramic image of items in three-dimension, importing data into the VR database for inventory management process in immersive ERP experiment.

Here, we compared the three properties for stereoscopic, resolution and precision. First, the stereoscopic, resolution and precision of input and output images were relatively low before 3D-reconstruction.

Then the experimental results show that, compared with the images of virtual objects in the ordinary VR database, the virtual objects reconstructed by the SSD block matching algorithm are more accurate in VR. The model has strong stereoscopic sense and their resolution and interaction are also better improved. It solves the problems of easy penetration, distortion and low resolution of virtual objects in the process of traditional VR technology interaction.

5. Conclusion

Based on panoramic image 3D-reconstruction algorithm of VR technology, ERP experiment system can intuitively show the actual operation of the ERP inventory management sand table simulation. By using 3D-reconstruction algorithm, the deeper information in two-dimension panoramic image can be accurately expressed, having higher accuracy, a more real scene, and better interaction effect virtual teaching environment. At the same time, it can enhance the simulation accuracy of the inventory items, so that the students can have better interaction in the simulated inventory business practice, and improve the students' training level and ability of practical operation. For the current traditional ERP teaching mode, under the aid of VR technology, emerging teaching mode has certain advantages. In view of the current trend, immersive ERP experiment has its validity of attempt to develop. Through VR technology, it enables students to be professional, improve students' docking ability, and improve the integrity cognition of students to ERP system and practical operation ability.

Finally, based on the ERP experimental model design of panoramic image 3D-reconstruction algorithm under VR technology, there are still many problems to be solved, this paper only for VR technology of ERP immersive experiment inventory management warehousing physical image problem is studied, how VR technology in ERP system in other fields and other processes also need deeper studies and discussions, which provides the direction for the future research.

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