



Design and Construction of Virtual Simulation Experimental Teaching Platform in Colleges and Universities Based on VR Technology

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Abstract. With the deepening of education informatization 2.0, the new teaching form under VR technology can fully expand the deep integration of teaching space and experimental teaching projects, form a brand-new teaching mode, and become an important measure to improve the quality and level of experimental teaching. In this regard, based on the problems of “three highs and three difficulties” in the current experimental teaching process in colleges and universities, this paper puts forward a set of construction scheme of virtual simulation experimental teaching platform, so as to achieve the purpose of experimental teaching reform and cultivating students’ innovative ability. With the help of the practical characteristics of VR technology, 3D digital modeling technology and Web3D visual interactive technology, and integrating the efficiency and convenience of Web application, the platform has formed a comprehensive software program integrating remote login, online teaching, virtual experiment, data processing and other functions, which not only reshapes the experimental teaching process but also promotes the further improvement of the experimental teaching system in colleges and universities. Practice has proved that all the functions of the system run smoothly, and the rendering speed of virtual scenes is obviously improved by relying on LOD and CULL algorithms, which strengthens the concurrency control of the platform and accelerates the development pace of information construction in colleges and universities while establishing a new paradigm of experimental teaching.

Keywords: VR technology · Virtual simulation experiment · Unity3D · Computer software application

1 Introduction

At present, China has entered a new era of Socialism with Chinese characteristics construction. The improvement of social development quality and efficiency, the constant adjustment of economic environment and the transformation and upgrading of industrial structure have all increased the demand gap for compound technical and technical talents [1]. In this context, colleges and universities, as the key positions for the training and output of professional talents, should grasp the pulse of the times, focus on new

systems, new forms and new tasks, give full play to the integration advantages of disciplines, talents and science and technology, comprehensively meet the requirements of the “innovation-driven development strategy”, actively promote the reform of education mode, innovate the path of talent training, and provide important talent protection for social and economic development. Faced with the disadvantages of attaching importance to theory but neglecting practice under the traditional teaching mode, although colleges and universities can make changes and breakthroughs in experimental teaching system, experimental teaching materials and laboratories, practical problems such as high investment, high loss, high risk and difficulty in implementation, application and circulation have become the shackles that restrict the development of experimental teaching in colleges and universities, so that the overall effect is not great [2]. In view of this, this paper holds that in the era of educational informatization, the reform of educational model in colleges and universities cannot be separated from the support of digital information technology. In view of the characteristics and teaching needs of experimental teaching in colleges and universities, this paper innovatively integrates VR technology into teaching practice, forming a teaching mode with virtual simulation experimental teaching as the core, and relieving the dilemma of being unable to do, not daring to do and not doing well in real teaching [3]. Under the guidance of computer software engineering, this paper puts forward a set of construction scheme of virtual simulation experiment teaching platform, which provides necessary technical support for the landing application of virtual simulation experiment teaching. The platform combines data information with functional services, and is encapsulated in the form of Web application, so that teachers and students can complete the corresponding experimental teaching tasks through simple operations. It is not only conducive to improving students' ability to integrate theory with practice, strengthening their awareness of innovation and practice, but also promoting the improvement of experimental teaching system in colleges and universities and promoting the process of information education construction in colleges and universities.

2 Platform Composition

The development content of virtual simulation experiment teaching platform in colleges and universities is divided into two parts. One is to complete the design, production and export of virtual experiment module based on 3ds Max, Unity 3D and other software. The other is to complete the overall structural framework of the platform in ASP.NET environment, and integrate and package all functional modules to form software applications.

First of all, for the design of virtual simulation experiment function module, the real experiment project will be selected as the blueprint. All kinds of scenes, tools, equipment and materials involved in the experimental project will be transformed into 3D digital models by 3ds Max software, and the materials, colors and luster of the models will be baked and rendered with Photoshop software to make the models more realistic and vivid, as shown in Fig. 1. After the design and construction of various models are completed, 3ds Max software will export all 3D digital models as.FBX files, and continue to complete the integration and assembly of models and scenes, the addition and

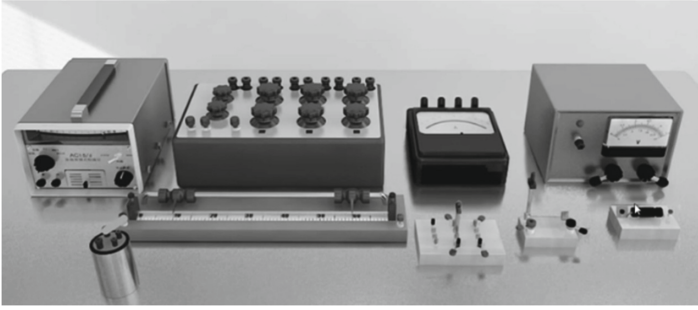


Fig. 1. Circuit experimental model

optimization of dynamic effects, the setting and processing of objects in the environment and the development of key interactive functions in Unity 3D software [4]. As the core of virtual scene experience, the design of key interactive functions needs to rely on a lot of script editing work, such as the change of perspective, the movement of position and the triggering of events. Interactive function can give users a more realistic sense of substitution and immersion [5] After all the designs are completed, all 3D data will be published to the Web by Unity 3D, that is, WebGL will be selected in Unity3D to export and generate specific index.html files and some resources and data packets.

Secondly, the overall development of the system is based on Windows10.0 operating system, the development environment of Web Server is. Net framework 4.7.1 matched with ASP.NET, the development language is C#, and the integrated development tool is Visual Studio Code. The Web server is Windows IIS 10.0, and the database is SQL Server 2019. After the system is fully developed, the index.html file exported from Unity 3D is imported into the project directory, and two methods, SendMessage () and Application.ExternalCall (), are selected to realize the interactive operation between the Unity3D program and the elements in the web page, and the real-time data transmission is realized through the interaction between the functions inside Unity and the methods on the web page [6].

Finally, all engineering project files in ASP.NET are packaged and distributed to IIS server. After configuring the corresponding ports, users can complete the use of the system from the client browser.

3 Functional Implementation

3.1 Student Side

a. Platform login and home page.

The platform has a unified login interface, and student users can enter the homepage interface through the client browser by entering their account numbers and passwords to complete identity verification. The platform includes several functional modules, such as announcement, virtual experiment, experimental results and online communication, and gives students corresponding functional permissions, so that students can choose their own applications.

b. Virtual experiments.

Under this function module, student users can choose different experimental projects or tasks to study according to the teaching arrangement or personal study plan. When student users choose and enter the virtual experiment, the platform will provide theoretical knowledge content and materials related to the experiment to deepen students' understanding of the experimental teaching content, such as practical training instruction video and PPT courseware.

After completing the experimental teaching, student users can enter the virtual experimental operation stage. The platform integrates 3D models, text pictures, audio and video and other elements to complete diversified display. It can support students to view and browse in a "naked-eye 3D" way, and can also complete interactive control operations through input devices such as keyboards and mice. [7] In addition, during the experiment, the platform can also support students to record and save the experimental data, which provides convenience for the subsequent experimental report writing.

In the platform, the experimental project has a complex scene structure, and there are many model objects. When student users perform interactive operations, it is easy to affect the rendering speed of graphics, increase the running load of the server, and even appear stuck and sluggish. In order to reduce this kind of influence and improve the efficiency of concurrency control, the platform adopts the Levels of Detail (LOD) technology to reduce the surface of the high model to obtain the low model, so as to optimize the image rendering rate [8]. Under LOD technology, the transformation from high mode to low mode depends on mesh simplification algorithm, which is commonly used triangle edge collapse algorithm. As shown in Fig. 2, it is the principle of triangle edge collapse, that is, two vertices of V and U are merged into one vertex of V . Each collapse will reduce two triangular faces, and on the premise of maintaining the original appearance of the model, iterative calculation will be carried out on the basis of completing the model with the least triangular faces. The calculation formula is shown in Formula 1, where T represents all triangular surface sets around vertex u and T' represents all triangular surface sets around vertices u and v [9].

$$\cos t(u, v) = \|u - v\| \times \max_{f \in T} \left\{ \min_{n \in T'} \{ (1 - f \cdot n) \div 2 \} \right\} \quad (1)$$

In order to verify the application effect of LOD technology in virtual reality experiment module, a set of simulation experiments will be set up, and LOD technology and CULL technology will be compared horizontally to obtain the corresponding test results. The test results are shown in Fig. 3. FPS represents the frame rate, CPU represents the

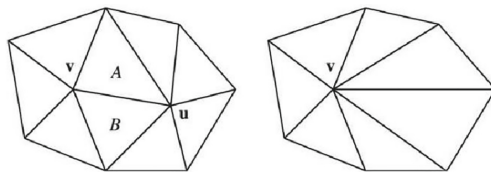


Fig. 2. Triangle edge collapse principle

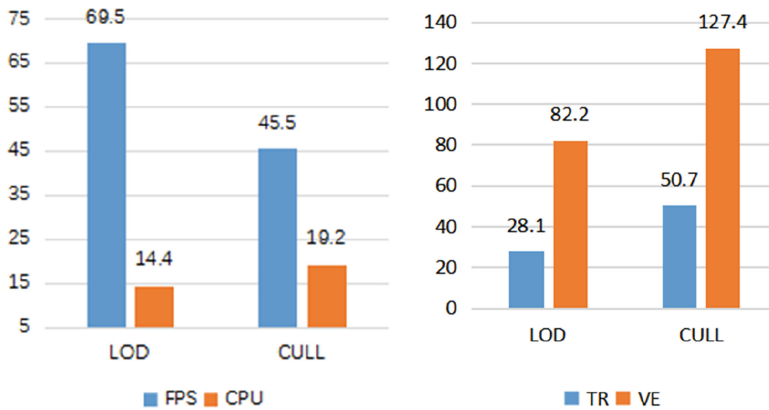


Fig. 3. Test results

proportion of system memory, TR represents the number of triangles in the model, and VE represents the number of vertices in the model. The results show that LOD technology can effectively improve the frame rate of virtual reality scene rendering, reduce the memory ratio and speed up the CPU operation. At the same time, LOD technology effectively reduces the total number of triangles and vertices in the model and reduces the rendering workload of the server.

3.2 Teacher Side

Under the virtual simulation experimental teaching platform, the functional authority of teacher users is mainly composed of three parts: student management, resource management and teaching management. As an important part of teaching management, assessment is an important standard for judging the effect of students' experimental learning. The platform can capture the learning behavior data generated by student users in the platform in real time, and preset the evaluation system standard of learning effect in advance according to the teaching objectives of experimental courses, as shown in Table 1.

The platform completes the construction of the judgment matrix for each index value, as shown in Formula 2. According to the judgment matrix, the elements of each row are normalized by the AHP hierarchical analysis method and then summed, and the obtained row vector is normalized twice to get the ranking weight vector W , and the corresponding weight λ_{\max} is calculated by the sum-product method, as shown in Formula 3 [10]. In order to verify the operation of the evaluation function of the platform, the platform uses the training data of 50 students to analyze and test, and the results of the experimental learning effect of a student user are shown in Table 2. The simulation test

Table 1. Remote training effect evaluation system

Learning behavior characteristics	Evaluation standards
Utility time A_{11}	≥ 25 class hours: 5 points, ≥ 15 class hours: 3 points, ≤ 10 class hours: 1 point
Login frequency A_{12}	≥ 5 times/week: 5 points, ≥ 3 times/week: 3 points, ≤ 1 time/week: 1 point
Experimental completion rate A_{21}	$\geq 80\%$: 5 points, $\leq 80\%$: 3 points, $\leq 60\%$: 1 point
Experimental completion number A_{22}	≥ 15 : 5 points, ≤ 15 : 3 points, ≤ 10 : 1 point
Experimental report results A_{31}	≥ 80 : 5 points, ≤ 80 : 3 points, ≤ 60 : 1 point
Experimental operation results A_{32}	≥ 90 : 5 points, ≤ 90 : 3 points, ≤ 60 : 1 point

Table 2. Evaluation results of students' experimental learning effect

Learning behavior characteristics	Weighted value	Single score	Comprehensive score
Utility time A_{11}	$C_{11} = 0.157$	3.75	4.03
Login frequency A_{12}	$C_{12} = 0.105$	3.81	
Experimental completion rate A_{21}	$C_{21} = 0.186$	4.04	
Experimental completion number A_{22}	$C_{22} = 0.179$	3.91	
Experimental report results A_{31}	$C_{31} = 0.236$	4.41	
Experimental operation results A_{32}	$C_{32} = 0.298$	4.38	

results show that the platform can automatically evaluate the effect of students' practical training, which provides necessary technical support for improving the effectiveness of experimental teaching in colleges and universities.

$$A = \begin{bmatrix} A_{11} & A_{12} \\ A_{21} & A_{22} \\ A_{31} & A_{32} \end{bmatrix} \quad (2)$$

$$\lambda_{\max} = \sum_{i=1}^n \frac{(AW)_i}{nW_i} \quad (3)$$

4 Conclusions

In order to improve the effectiveness of experimental teaching in colleges and universities, this paper puts forward a set of construction scheme of virtual simulation experimental teaching platform based on the "three highs and three difficulties" problems faced in the teaching practice. The platform takes the virtual reality technology as the core, realizes the high restoration and reproduction of the virtual simulation experimental

environment and experimental projects, and combines theoretical knowledge teaching with experimental operation to create a new ecology of experimental teaching in the era of educational informationization. In the follow-up research, the platform will further enhance the richness of virtual reality experimental scenes, optimize the interactivity of the experimental process, and provide technical support for the cultivation of compound technical and technical talents.

References

1. Wu Yuwen et al. Research and Practice on the Training Path of Compound Technical Talents [J]. *Internal Combustion Engine & Parts*.2022.09.
2. Zhang Lin et al. Exploration and Reform of the Present Situation of Experimental Teaching in Colleges and Universities [J]. *Chinese Medicine Modern Distance Education of China*.2020.01.
3. Ren Lijun. Innovative Practice of Experimental Teaching Based on Virtual Reality Technology [J]. *Electronic Technology*.2022.07.
4. Ning Xin et al. Research and Application of 3D Modeling Technology in Virtual Reality [J]. *SP*.2018.08:75.
5. Song Chuanlei, Hou Shizhong. Unity3D Virtual Reality Scene Analysis and Design [J]. *China Market*.2017.06.
6. Li Long. Application Research of Virtual Environment Simulation and Human-computer Interaction Based on Unity3D [D]. University of Electronic Science and Technology of China.2018.09.
7. Fang Lisheng. Research and Implementation of Visual Control Simulation Teaching Experiment Platform Based on Unity3D [D]. Harbin Engineering University.2021.03.
8. Yan Shuang et al. Research and Application of Virtual Scene Modeling Method Based on LOD Technology [J]. *Geomatics & Spatial Information Technology*.2021.09.
9. Ding Tianmei, Xu Fada. Research on LOD Technology of Multi-level Details in 3D Model [J]. *Practical Electronics*.2021.09.
10. Zhou Kaiquan. Comprehensive Evaluation of Learning Effect of Mixed Teaching Based on Data Mining [J]. *China Educational Technology & Equipment*.2019.11.

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