Design and Construction of Forensic Material Evidence Simulation Experiment System Based on Virtual Reality Technology

Lugui Hao(✉)

SiChuan Judicial and Police Officers Professional College, DeYang 618000, Sichuan, China
957670052@qq.com

Abstract. In order to cultivate practical forensic professionals in the new era, this paper takes the experimental course of forensic material evidence as the research object, and integrates the unique advantages of virtual reality technology, network information technology and computer application technology to build a Web-based forensic material evidence simulation experimental system. The whole system belongs to B/S architecture, the front-end interactive page is developed by VUE framework, and the back-end is built by SpringMVC framework under J2EE specification, and Tomcat completes the functional operation and logical control of the experimental system. The system realizes the high restoration and reproduction of the virtual simulation experimental environment and experimental projects through 3ds Max, Unity3D and other software programs. This not only helps to improve students' comprehensive ability and professional accomplishment, but also helps to overcome the disadvantages of traditional experimental teaching mode. It can also use AHP data analysis algorithm to complete the evaluation of students' learning effect, and provide an effective new mode and method for cultivating high-quality applied criminal investigation technical talents.

Keywords: VR technology · forensic material evidence science · Unity3D · virtual simulation experiment · computer application

1 Introduction

As the main course of forensic medicine, forensic material evidence science aims to complete the identification of human biological samples by various means of life science and technology, and provide scientific evidence and basis for solving medical problems related to law. [1] The course of forensic material evidence is highly practical, and experimental teaching occupies a large proportion in all teaching contents, which is the key link to ensure the teaching effectiveness and improve students' professional quality and comprehensive ability in actual combat. However, in the process of experimental teaching, there are still some problems, such as the lack of innovation in routine experiments, the limitation of time and space in course development, the inability of experimental projects to restore the real crime scene, and the high cost of experimental equipment and consumables to practice repeatedly. [2] In view of this, this paper holds that in order to

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strengthen the effectiveness of forensic material evidence experiment teaching, colleges and universities should actively play the characteristics of virtual reality technology, network information technology and computer application technology, design software with 3ds Max and Unity3D as the core, and combine with Java development environment to build a Web-based forensic material evidence simulation experiment system. The system innovatively introduces the virtual simulation teaching method and online teaching form into the experimental course of forensic material evidence, which helps to solve the pain points of the traditional experimental teaching mode and has important practical significance for cultivating high-level forensic talents needed for actual combat [3].

2 Development Process

First of all, the design and planning of the virtual simulation experiment function module of forensic material evidence will take Unity 3D as the virtual simulation engine, combine 3D digital modeling, animation simulation, human-computer interaction and other means, and combine two-dimensional and three-dimensional display modes to build a complete set of virtual scenes. [4] The main scenes include the crime scene, forensic autopsy room, trace inspection room, DNA inspection room, other material evidence technical inspection room and case center. Each scene and all objects in the scene will be based on real 3D data, and the corresponding models will be made in 3ds Max software. After the modeling is completed, the map will be baked to make the model more realistic and vivid, and the production of the map material needs to rely on Photoshop software for details processing. [5] After the design and construction of various models are completed, 3ds Max software exports all 3D models as. FBX files, and introduces such files into Unity 3D. In Unity 3D software, the integration and assembly of models and scenes, the addition and optimization of dynamic effects, the setting and processing of objects in the environment, and the development of key interactive functions will be completed.

The realization of interactive function will rely heavily on the editing and processing of script code. For example, the change of user's viewing angle, the selection, operation and control of objects in the scene, and the interaction of relevant experimental data, text and picture information. In Unity 3D, users can use C#, UnityScript and other languages to complete the design and development of various functions, as shown in Fig. 1 for the mouse wheel to control the zoom function code. [6] After all the designs are completed, all the 3D data will be published to the Web by Unity 3D, that is, Unity3D will be selected and WebGL will be exported. After the project is exported, all content-specific files containing WebGL are generated.

Secondly, the overall development of the system is based on Windows10.0 operating system, the basic development environment is Java, the JDK version is 1.8 and above, and the integrated development tool is Eclipse Neon 4.6.2. Apache Tomcat 9.0 is selected as the Web server, MySQL 5.7 as the database, and project object model (Maven) is used to manage the project structure. Maven selects Apache-Maven-3.2.1 version. [7] The overall design of the system will be divided into two parts. The front-end development takes VUE framework as the core, combined with MVVM data binding and composable

```
if(Input.GetAxis("Mouse ScrollWheel")!=0)
{   var moveDistance =Input. GetAxis("Mouse ScrollWheel")* ScaleSpeed;
    var position=transform position;
    position+=transform.TransformDirection(Vector3.forward).nomalized*moveDistance;
movePosition(position);
}
```

Fig. 1. User-controlled viewing angle zoom function code

component system, the incremental development of the Web front-end can be completed quickly. The server-side development relies on the SpringMVC framework to complete the design. Through the introduction of the above key technical theories, the overall environment of system development, the configuration of related software and tools are determined, and the technical feasibility of the overall project of forensic material evidence simulation experiment system is also clarified.

3 Detailed Function Realization

3.1 Student Side

The main functions of the student side include case checking system, on-site inspection system and material evidence inspection system.

The case checking system corresponds to the case center scene. Under this function module, student users can fully feel and be familiar with the whole process of case acceptance and appraisal. The student users can choose different types of virtual simulation cases independently, and quickly obtain the time, informant, case handler, case brief, etc. of the case through the case briefing, which is convenient for the student users to quickly grasp the key points of the on-site inspection of forensic material evidence.

After selecting a virtual simulation case, student users can enter the scene of the virtual simulation case in the form of visual interaction. Common forensic material evidence in the scene of virtual simulation cases includes human tissues and organs and fragments, body fluids, secretions and excretions, as well as footprints, fingerprints, crime tools and so on. For different material evidence, student users need to choose the corresponding sample extraction method, and determine the packaging, storage methods and inspection process at one time [8].

Under the physical evidence inspection system, student users will make a virtual material evidence inspection scheme according to different materials to select the appropriate experimental methods for material evidence inspection. Different DNA extraction methods are combined with the subsequent DNA typing system to interpret the genotyping results. As shown in Table 1, the formula for calculating the likelihood ratio of X-STR loci in male-male individual identification is given. Finally, the data is processed according to the atlas and the final identification document is issued [9].

Table 1. Calculation formula of X-STR male individual identification

Relationship categories	Ggenetype	Likelihood ratio calculation formula
Siblings; Half-brother; Grandfather and grandson	Xp, Xp	$(1 + m_p)/2m_p$
	Xp, Xq	1/2
Uncle and nephew	X_p, X_p	$(1 + 3m_p)/4m_p$
	X_p, X_q	3/4

Note: X is chromosome, p and q are alleles, and m_p is allele frequency

Table 2. Evaluation system of learning effect

Primary indicators	Secondary indicators	Weighted value	Hierarchical consistency ratio CR
Learning attitude	System usage time	0.015	0.0521
Learning process	Learning progress	0.028	
	Completion degree of the qualification report	0.031	
Learning effect	Experimental ability	0.066	
	…	…	

3.2 Teacher Side

After the teacher user logs into the system, the main functions include case development and statistical evaluation. Under the case development function, teachers can complete the setting of all kinds of case elements according to the real cases, and reproduce the process of criminal suspects' committing crimes by comprehensively analyzing the shape, color, distribution and other information of physical evidence spots on the scene of virtual simulation cases. [10] Under the statistical evaluation module, the system will use AHP hierarchical analysis method to build a learning effect evaluation system, and score according to the actual performance of students in the system, as shown in Table 2 for the learning effect evaluation system, and the formula for calculating the hierarchical consistency ratio is shown in Formula 1.

$$CR = \frac{CI}{RI}, CI = \frac{\lambda_{\max} - \mathrm{n}}{\mathrm{n}\text{ - }1}, RI = \frac{\sum_{\mathrm{n}}^{i} CI_i}{\mathrm{n}}. \quad (1)$$

4 Conclusion

In order to improve the comprehensive ability and professional quality of forensic material evidence professionals in colleges and universities, and seize the important opportunity of digital transformation and upgrading of modern education, this paper takes

practical teaching as the starting point, and builds a forensic material evidence simulation experiment system with the application advantages of virtual reality, network information technology and computer application technology. The system has effectively promoted the information reform of the experimental teaching mode of forensic material evidence, and provided a useful attempt for the cultivation of practical technical talents of forensic specialty in the new period.

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