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VR and Somatosensory Technology-Integrated Immersive Teaching Interaction System Design

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Abstract: The contemporary traditional teaching model dominated by teacher lectures can no longer fully meet the rapidly evolving educational needs in the information age. Teaching is confined to textbook materials, unable to keep pace with the t imes or align with application environments and job requirements, thereby affecting students' future employment scenarios. Passive learning also diminishes students' interest and reduces teaching quality. This paper designs and applies a VR -based intelligent somatosensory teaching interaction system to create a virtual immersive learning environment, enabling students to experience application scenarios firsthand, satisfying their psychological and interactive needs, and thus influencing their external be haviors. At the same time, the system can generate diverse teaching scenarios, replacing multiple experimental environments and meeting the teaching needs of various disciplines, which holds practical significance for future real-world teaching applications.

Keywords: Virtual reality technology, Curriculum reform, Teaching interaction system, Digital media art design, Artificial intelligence.

1. Introduction

The contemporary traditional teaching model, primarily relying on pre-recorded lectures, video resources, and PowerPoint presentations, has become increasingly inadequate in meeting the rapidly evolving educational demands of the information age. Teaching confined to textbooks and classroom environments has become the norm in higher education. This inability to adapt to technological advancements and align with real-world application scenarios and job requirements directly impacts students' preparedness for future employment.

Although universities have made efforts to improve teaching conditions, practical limitations remain unresolved due to the following challenges:

(1) Safety concerns during field trips

To enhance students' learning experiences, instructors often organize on-site visits. However, off-campus activities pose significant safety risks, placing dual demands on instructors' responsibilities and capabilities. Many educators opt for classroom-based video lectures instead of fieldwork to mitigate these risks.

(2) Restricted access to practical training environments

While corporate visits are common practice, limited industry partnerships often restrict students to superficial observations rather than meaningful engagement. Insufficient enterprise collaboration prevents in-depth exploration of authentic workplace environments.

(3) Budget constraints for equipment investment

Traditional teaching models require specialized laboratories with scenario-specific equipment. High costs associated with setup and maintenance deter universities from investing in advanced experimental facilities, compromising hands-on learning opportunities.

Given these challenges, there is an urgent need to transform classroom infrastructure. With advancements in technology and the proliferation of virtual reality (VR), immersive virtual-reality integration environments represent the next frontier in educational innovation. Implementing VR-based intelligent somatosensory interaction systems offers promising solutions to enhance student engagement and instructional efficiency.

This paper explores the design and application of an immersive teaching system leveraging VR and somatosensory technology. By creating virtual simulation environments, students gain firsthand experience in professional scenarios, addressing psychological and interactive needs while influencing behavioral outcomes. The system's ability to generate diverse teaching scenarios replaces multiple physical laboratories, reducing costs associated with facility construction and field trips. This innovation holds significant practical implications for future educational practices.

2. Overview of the Design Scheme for an Intelligent Motion-Sensing Teaching Interaction System Based on Virtual Reality Technology

2.1. Design Concept for an Intelligent Motion-Sensing Teaching Interaction System Based on Virtual Reality Technology

The design of an intelligent motion-sensing teaching interaction system based on virtual reality technology begins by constructing a virtual environment using tools such as 3Dmax and Unity3D, tailored to the specific application scenario. This virtual environment is then integrated with VR motion-sensing devices to create an immersive mixed-reality environment. Teachers can select virtual scenes according to the teaching content, and the learning data generated during the course is synchronized to both PC and mobile platforms. This allows students to review course content after class and continue offline learning. The design and application process are illustrated in Figure 1:

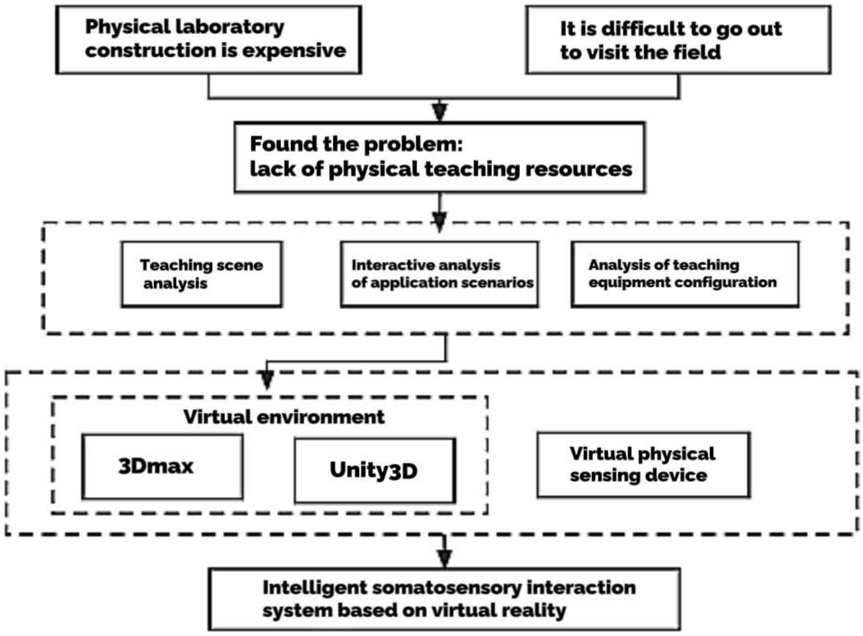

Figure 1. Design Concept of an Intelligent Motion-Sensing Teaching Interaction System Based on Virtual Reality Technology

2.2. Overview of the Design Scheme for an Intelligent Motion-Sensing Teaching Interaction System Based on Virtual Reality Technology

The overall design scheme of the intelligent motion-sensing teaching interaction system based on virtual reality technology consists of four parts, as shown in Figure 2:

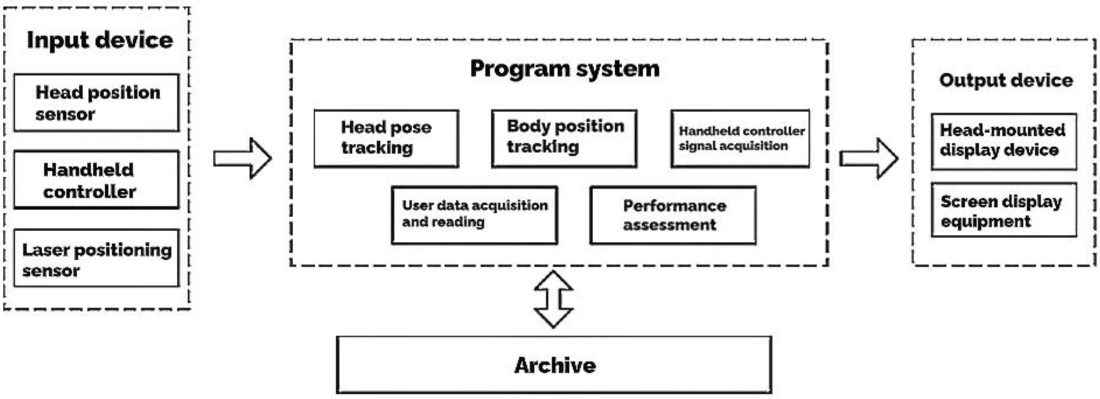

Figure 2. Overall Design Scheme of the Intelligent Motion-Sensing Teaching Interaction System Based on Virtual Reality Technology

2.2.1. Input Devices

The input devices include a head position sensor, handheld controllers, and a laser positioning sensor. Users experience the system's scenarios through output devices and react to the scenarios, with feedback provided to the program system via input devices. The purpose of the system design is to inspire students' enthusiasm for learning by creating a realistic and open learning environment. By utilizing virtual interactive technologies, students can actively participate in exploring and learning knowledge. This teaching method not only enhances student engagement but also helps them actively seek and master effective problem-solving methods [1]. Learners can interact with learning scenarios through input devices, understand the workflow of real scenes, specific operations of scene facilities, or rehearse for unexpected scenarios within the scene. Input devices serve as the bridge for interacting with scenarios, enabling interaction with the scene.

2.2.2. Program System

The program system is the most critical component of the intelligent motion-sensing teaching interaction system based on virtual reality technology. Its primary functions are twofold:

(1) Tracking and Feedback: Responsible for tracking the position of the head and body, processing input requests from handheld controllers, and adjusting the system environment display. Motion-sensing devices capture every movement of the user with precision. Through advanced recognition and parsing technologies, the user's body language is translated into corresponding actions of the character in the game and interactions with the virtual scene. This innovative interaction method provides users with an immersive experience, making them feel as if they are in the game world, enjoying unprecedented realism and participation [2]. During the process of experiencing the scene through input devices, learners continuously generate interaction data. This data is fed back to the program system, which processes it efficiently and promptly. As a result, the system can respond in a timely manner, ensuring the stable operation of motion - sensing devices and interaction terminals. This optimized data

processing capability delivers a smooth and seamless interaction experience for users.

(2) Read and Store User Data in the Database: The program system reads user data from the database and stores user data and grades in it. The teaching interaction system is designed to allow students to interact and learn across multiple platforms. Thus, the program system must have student information storage functions, integrating user data and grades generated during usage scenarios into the database.

2.2.3. Database

The database serves two main purposes. Firstly, it stores scenes from the film and television synthesis resource library, which can be invoked based on learners' needs. Secondly, it stores users' personal information and assessment grades. Teachers can find suitable teaching scenes through the database, select them for application, and store data generated during usage. Database content can be exported and synchronized to PC and mobile platforms.

2.2.4. Output Devices

There are two types of output devices: head-mounted displays and screen display devices, both of which can present realistic virtual scenes to users.

Head-Mounted Displays: Primarily VR glasses, these devices output visual effects and audio, enhancing users' sense of participation and immersion in the system for an immersive experience. They significantly reduce external distractions, improving learners' focus and learning efficiency during scene usage.

Screen Display Devices: These devices can display system content externally, allowing learners without VR glasses to view scene content and operator demonstrations, enabling them to gain interactive learning experiences through the operator's interactions.

3. Implementation of the Overall System Design Scheme

The development of the intelligent motion-sensing teaching interaction system based on virtual reality technology is divided into three stages:

(1) Digital Modeling of Virtual Scenes;

(2) Design and Implementation of the Program System;

(3) Integration and Experience of Interactive Devices.

The development work for each stage is detailed below.

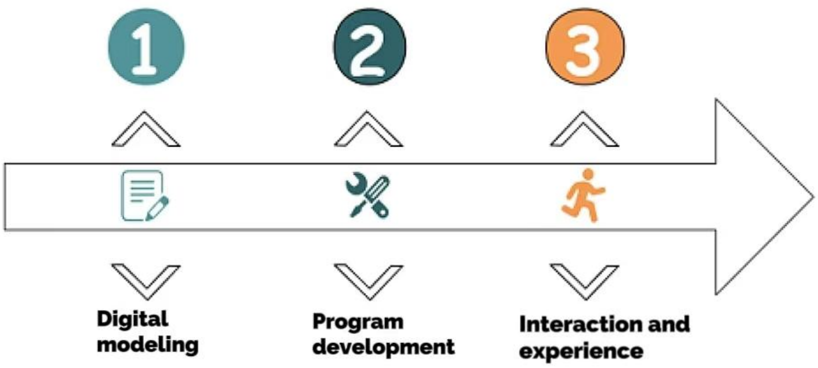

Figure 3. Development and Implementation Stages of the Intelligent Motion-Sensing Teaching Interaction System Based on Virtual Reality Technology

3.1. Digital Modeling of Virtual Scenes

The virtual scenes from the film and television synthesis resource library are the actual experiential content of the interactive system mentioned in this paper. Therefore, the content generation phase is crucial and indispensable. The primary focus of this stage is to efficiently produce realistic experiential content. The solution adopted in this paper is 3DMAX combined with Unity3D to achieve the final goal. Digital modeling can be subdivided into geometric modeling, physical modeling, and behavioral modeling.

(1) Geometric Modeling

Geometric modeling describes the geometric information of objects, including their shape and appearance. Depending on the specific circumstances of these elements, different geometric modeling methods can be employed. These include polygon modeling, NURBS (Non-Uniform Rational B-Spline) modeling, and Subdivision (subdivision surface technology) modeling.

Polygon Modeling: The most basic modeling technique, allowing editing with a small number of meshes. The basic modeling approach is to first outline a basic geometric shape and then modify the details of the object as needed. Its drawback is the inability to directly generate curved surfaces.

NURBS Modeling: Primarily used for creating curved surface objects. NURBS curves can be split and merged at any point, which polygon modeling curves cannot achieve. However, it cannot be used to create sharp edges.

Subdivision Modeling: A new modeling technique that combines the features and advantages of NURBS and polygon modeling. It is suitable for building complex models with rich layers and is ideal for creating still frame works.

Geometric modeling is primarily completed using 3DMAX.

(2) Physical Modeling

Physical modeling achieves model construction by simulating object displacement, collision detection, selection, and surface deformation. There are two main technical approaches: fractal technology and particle systems.

Fractal Technology: Often used to represent complex and irregular physical objects, initially used for modeling mountains and water flows. However, due to its high computational requirements, it is rarely used in dynamic real-time interactive systems.

Particle Systems: Simple to operate and primarily used for modeling a large number of dynamically moving objects, such as flowing water, wind, snow, and rain.

Physical modeling in this paper is completed using Unity.

(3) Behavioral Modeling

In addition to considering the shape and appearance of objects during model construction, it is essential to associate the physical properties of real objects to ensure realistic reactive responses. This is where behavioral modeling comes into play, primarily responsible for designing the motion behavior descriptions of objects.

Behavioral modeling is also completed within Unity.

In summary, selecting the most appropriate modeling method based on actual requirements is essential to achieve the desired effects quickly and efficiently.

3.2. Design and Implementation of the Program System

Unity, as a mature commercial physics engine, serves not only as the primary tool for digital modeling in the virtual interaction system described in this paper but also as the main development tool for the program system. Figure 4 illustrates the primary design approach of the program system in the virtual interaction system described in this paper.

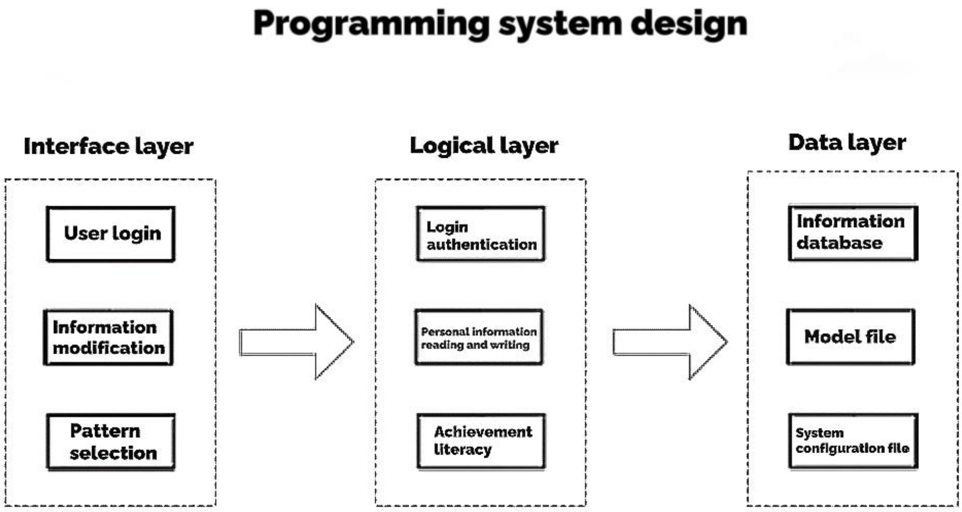

Figure 4. Primary Design Approach of the Program System

The interface layer is the main entry point for users to exchange information with the virtual interaction system. Its main functions include user account registration and player login. After successful account login, users can select the corresponding scene mode based on the assessment

content to enter the relevant virtual scene. Within the virtual scene, players can move freely within a limited area or use handheld controller buttons to navigate or switch scenes. In addition to the above interactions, users can control the crosshair in VR glasses via a head-mounted position sensor to interact with scene UI or interactable objects. This is achieved by emitting a ray from the crosshair position in real-time. When the ray detects prolonged contact with UI elements or interactable objects, it triggers interactive events. In certain scenes, users can use the controller to move virtual hands to grasp objects and move them to target points. This process utilizes collision detection and IK inverse kinematics to make interactions between virtual hands and objects more realistic.

The logic layer is primarily responsible for user account verification, reading and writing personal information, and reading and writing grades. The interaction logic described above also falls under the functionality of the logic layer. Specific tasks include data file parsing, scene navigation, step initialization, grade entry, collision detection, operation calculation, interaction intent recognition, and automatic demonstrations.

The data layer stores all user personal information, system configuration files, and model files.

3.3. Integration and Experience of Interactive Devices

The VR interactive devices used in this system primarily include five sensing devices: one HTC headset, two handheld controller handles, and two laser positioning sensors. The concave points on the front of the headset are tracking sensors, with a camera lens located below the front. The handles are handheld devices through which users operate objects in the virtual scene. The role of the positioning sensors is to obtain the positions of the handles and the headset. Figure 5 is the interaction flowchart of the interactive system described in this paper, intuitively displaying the information exchange process between users and the interactive system.

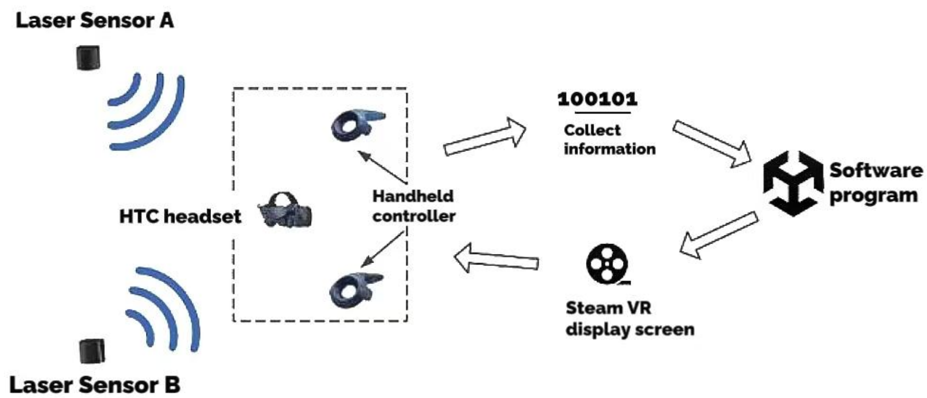

Figure 5. Interaction Flowchart of the Interactive System

4. Operation Process of the Intelligent Motion-Sensing Teaching Interaction System Based on Virtual Reality

As shown in Figure 6, the design of the interactive system's operation is based on real teaching scenarios. By selecting appropriate virtual scenes from the system according to teaching requirements, learners can experience immersive scene experiences, as shown in Figure 7. The learning data generated is stored in the system database. On one hand, learning data is sent to PC and mobile platforms for learners to review and recall. During the learning process on these platforms, data is synchronized and updated back to the interactive system. On the other hand, feedback data is transmitted to the film and television synthesis resource library to serve as a reference for library updates. This improves the teaching models in the virtual scenes through feedback data.

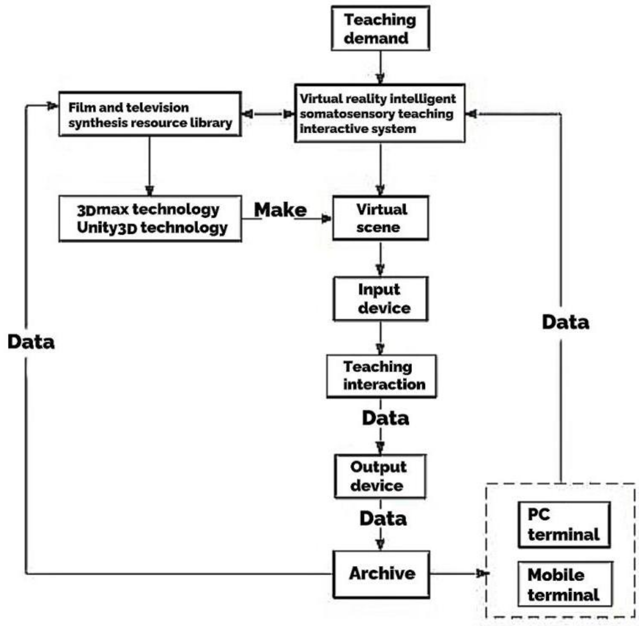

Figure 6. Operation Process of the Intelligent Motion-Sensing Teaching Interaction System Based on Virtual Reality

Figure 7. Immersive Scene Experience

5. Conclusion

By using motion-sensing interaction, learners can gain immersive scene-based learning experiences. Combined with multi-platform data sharing from the database, this approach enhances understanding and application of knowledge content. This paper combines film and television synthesis resource libraries with VR motion-sensing devices to develop an intelligent motion-sensing teaching interaction system based on virtual reality. It explores the design approach of this system, offering a new way to improve teaching conditions in higher education institutions in the future.

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