Design of a Virtual Reality-Based Professional Simulation Training System for Elderly Care

Fang Liu

149615937@qq.com

Shandong Xiehe University, Shandong Ji'nan 250100, China

Abstract: To address the current issues of limited practical training conditions, narrow scenarios, and a disconnect between theory and practice in elderly care professional training, this article proposes the design of an immersive virtual simulation system for elderly care training. This system adopts a three-tier architecture and utilizes virtual reality technology to create diverse nursing scenarios and interactive modes. Typical scenarios in the system include hospital wards and home care, offering mixed interactions between physical and virtual objects. The system achieves high-fidelity environmental rendering and interaction simulation using the Unity 3D engine, creating an immersive experience through devices such as head-mounted displays. Compared to traditional teaching methods, this virtual simulation system provides realistic scenarios and natural interactions, enhancing students' interest and training effectiveness. By effectively leveraging virtual reality technology, this system establishes an immersive training environment for elderly care, seamlessly integrating theoretical instruction with clinical practice, thus significantly enhancing the quality of elderly care professional training.

Keywords: Virtual Reality; Elderly Care; Simulation

1. Introduction

Virtual reality technology is widely applied in the construction of medical training platforms, providing immersive three-dimensional training environments [1]. Existing research has shown that utilizing virtual scenario training can effectively enhance the nursing skills of learners [2]. However, the specific design of virtual environments and human-computer interaction experiences for geriatric nursing professionals requires further exploration. This study, leveraging the advantages of virtual reality technology and starting from the practical needs of geriatric nursing training, aims to design a virtual simulation training system tailored to the field of geriatric nursing. Through research on system requirements analysis, design, scene implementation, and training evaluation, we seek to explore the creation of a high-quality virtual training system for geriatric nursing. This endeavor not only enriches the means of geriatric nursing training but also serves as a reference for virtual training in other medical disciplines. The research objective is to demonstrate that the designed system can effectively enhance the quality of geriatric nursing training. The full text will provide a detailed explanation of the system's analysis, design, and evaluation processes.

ICIDDT 2023, November 03-05, Zhenjiang, People's Republic of China

DOI 10.4108/eai.3-11-2023.2342229

2. System Requirements Analysis

2.1 Functional Requirements

The functional requirements of the elderly care simulation training system include providing diverse simulated nursing scenarios, supporting the configuration of physiological parameters for the elderly, simulating daily care operations for the elderly, and supporting multi-user collaborative training. The system needs to provide training in basic nursing skills such as feeding, bathing, and physical therapy. It also needs to set comprehensive nursing tasks to assess the trainees' comprehensive nursing abilities. To monitor trainee performance, the system should provide trainee operation records and evaluation functions.

2.2 Technical Requirements

Technically, the system needs to support virtual reality devices to create an immersive training environment. It needs to build realistic 3D nursing scenes and character models that support interaction with characters. The system needs to simulate the use of various medical devices and allow the setting of virtual characters' physiological parameters. To ensure system performance, efficient 3D scene rendering technology needs to be employed while handling real-time interaction with users. The system also needs to be developed and deployed using virtual reality software and hardware platforms[3].

2.3 User Experience Requirements

The system needs to provide an immersive virtual nursing environment that allows users to immerse themselves in simulated scenarios. The 3D models and scenes need to closely mimic real environments and characters, and user actions should provide realistic feedback. Personalized virtual characters with different medical conditions need to be provided. The interface should be simple and user-friendly, reducing user difficulty. The system should be responsive and realistically simulate scenarios to give users a sense of presence [4].As shown in Table 1.

Table 1 User Experience Requirements

User experience requirements	significance	Implementation mode
An immersive virtual nursing environment	high	Realistic scenes and interactive experiences
Highly simulated real environments and characters	high	Detailed 3D modeling and animation
Personalized avatar Settings	In the	Users can customize the virtual character attributes
Simple and easy-to-use interface	In the	Intuitive user interface design
Fast response to user input	high	Low latency user interaction response

3. System Design

3.1 System Architecture Design

The system adopts a three-tier architecture consisting of the simulation layer, control layer, and display layer. The simulation layer primarily handles the modeling of elderly patient information. It can predefine personal information and medical case details for virtual elderly characters and simulate various psychological and physiological parameters of the elderly, such as vital signs and emotional states. Data transfer within the simulation layer can be represented as follows:

$$D_{\text{simulate}} = f(P_{\text{Elderly information}}, E_{\text{Case information}}) \quad (1)$$

The control layer is responsible for performing the initialization configuration of the entire system, managing training scenario modes, handling student interaction events, and serving as the bridge between the simulation layer and the display layer, coordinating the flow of information among various modules of the system. The event handling in the control layer can be represented as follows:

$$E_{incident} \rightarrow C_{Controls} = g(E_{incident}) \quad (2)$$

The display layer primarily handles the rendering and display of the three-dimensional virtual scenes, including the three-dimensional modeling of nursing environments, characters, interactive objects, and the real-time rendering of images. It also supports the output of voice information and the presentation of interactive interface effects. The modular design of these three layers ensures a rational system architecture with clear functionality, facilitating system expansion and maintenance [5].

3.2 Simulation Scenario Design

The system has constructed two virtual scenarios, simulating two typical elderly care environments: community and hospital. The first scenario is the virtual environment of Donghai Rehabilitation Center, which simulates the daily life of the elderly in a community setting, including areas like bedrooms, dining rooms, activity rooms, and medical offices. In this virtual scenario, students can experience providing daily living care, psychological support, and medication guidance to elderly community residents. The second scenario is the virtual environment of Xishan Hospital, which primarily simulates a professional medical environment, including wards, diagnostic areas, treatment zones, and nurse stations. In this hospital virtual scenario, students can practice using medical equipment and perform professional patient care and medical procedures. These two scenarios closely resemble real-life elderly care work environments, contributing to a comprehensive improvement in students' service capabilities [6].

3.3 Interaction Design

The system supports various natural interaction methods to enhance the immersion and realism of the virtual environment. These methods can be categorized into two main types: voice interaction and gesture interaction. Voice interaction encompasses voice command recognition, allowing students to control virtual character actions and access menus using

voice commands. It also includes voice questioning, primarily used for simulating voice dialogues between virtual characters. Gesture interaction enables students to touch and manipulate virtual objects and equipment using their hands, such as caressing virtual characters, adjusting bed heights, and moving wheelchairs, thereby achieving a more realistic environmental interaction process. Additionally, the system supports full-body movement and head tracking as natural interaction methods, allowing students to freely explore the virtual three-dimensional scenes and create a genuine sense of presence [7].

4. System Implementation

4.1 Key Technologies

The system is developed using the Unity 3D game engine, which supports deployment on multiple platforms. Voice interaction is implemented through the integration of voice recognition, natural language processing, and speech synthesis technologies. Immersive scene presentation is achieved by integrating the Oculus Rift virtual reality device. Realistic character interaction is realized through the use of simulation human dynamics algorithms [8].

4.2 System Modules

The system comprises scene modules, interaction modules, evaluation modules, and more. The scene module creates multiple three-dimensional virtual environments, such as hospital wards and settings. The interaction module recognizes voice and gesture interactions. The evaluation module records student operation data in various scenarios and conducts skills assessments [9].

```
SceneModule:
    Initialize()
        // initialize scene module
    LoadVirtualScenes()
        // load 3D models of virtual scenes
   InteractionModule:
    Initialize()
        // initialize interaction module
    RecognizeSpeech()
        // recognize speech
    RecognizeGestures()
        // recognize gestures
    EvaluationModule:
    Initialize()
```

```
        // initialize evaluation module
    RecordTraineeOperations(data)
        // record trainee operations
    AssessSkills(data)
        // assess skills based on recorded data
```

4.3 System Testing

In two virtual scenarios, namely the East Sea Rehabilitation Center and the West Mountain Hospital, a subjective evaluation test was conducted with a sample of 20 nursing students. The results are presented in Table 2.

Table 2 Summary of System Test Results

Evaluation index	Average score (out of 5)	Excellent rate (>=4 points)
immersion	4.2	85%
Interactive realism	4.0	80%
Scene fidelity	4.1	80%
Interactive naturalness	4.3	90%
Training effect	4.5	95%

From the table, it can be observed that the average scores for immersion and interaction realism are relatively high. The excellence rate for scene realism and interaction naturalness also exceeds 80%, with 95% of the students believing that the system is beneficial for improving nursing skills. The comprehensive results indicate that the designed virtual reality geriatric nursing training system has achieved a satisfactory level of simulation and training effectiveness [10].

5. Conclusion

In this paper, a simulation training system for the elderly care profession was designed using virtual reality technology. Through the analysis of system functional requirements, technical requirements, and user experience requirements, a system architecture design was proposed, consisting of the simulation layer, control layer, and display layer. Two virtual scenarios, Donghai Rehabilitation Center and Xishan Hospital, were designed to support multiple interaction modes, including voice and gesture interaction. Key technologies such as Unity 3D engine and voice interaction were applied, and system components like scene modules, interaction modules, and evaluation modules were developed. Through testing, the system's simulation realism and training effectiveness were validated, achieving the design goal of using virtual reality technology to assist in elderly care professional training. This system is expected to enhance the efficiency and effectiveness of elderly care training.

References

[1] Nurkertamanda D , Frendiansyah F , Saptadi S ,et al.Virtual laboratory application based on virtual reality simulation as training tool of turning machine using goal-directed design method[J].IOP Conference Series: Materials Science and Engineering, 2021, 1072(1):012077 (7pp).

[2] Veldmeijer L , Terlouw G , Veer J V ' ,et al.Harnessing virtual reality simulation in training healthcare workers in handling patients with suspected COVID-19 infections: results of training and lessons learned about design[J].Design for Health, 2022.

[3] Amini H , Gregory M E , Abrams M A ,et al.Feasibility and usability study of a pilot immersive virtual reality‐based empathy training for dental providers[J].Journal of Dental Education, 2021(11).

[4] Heckmann, Frieder , M. Hedderich , and M. Heimberger . "Process for an integrated design for the modeling, simulation and testing of a real-time architecture within a model-based system and software development.", DE102020102996A1. 2021.

[5] Ke T, Guang G , Xin P ,et al.Design of a Simulation Training System for Arthroscopic Knee Surgery[J].Computer Simulation, 2009, 26(12):290-290.

[6] Haoze Z, Weijian L , Dong L .Design and Implementation of Simulation Training System for Electric Energy Measuring Instrument Based on Virtual Reality Technology[J].Automation & Instrumentation, 2016.

[7] Azarmdel H , Mohtasebi S S , Jafary A ,et al.Design and Simulation of a Vision-Based Automatic Trout Fish-Processing Robot[J]. 2021.

[8] Lu Y U, Shao-Wen J , Zhi-Dong J .Design and Implementation of the Simulation Operation Training System Based on Virtual Reality Technology[J].Instrumentation Technology, 2017.

[9] Lei W, Wu-Ping L I , Xiang-Yang S .Design of Display-interactive Simulation Training System for "Five-Skill" Technique of Warfield Rescue[J].Nursing Journal of Chinese People's Liberation Army, 2008.

[10] Shelly. High-fidelity nursing simulation and the impact on self-confidence and clinical competence of senior nursing students[J]. 2013.