AN INTUITIVE AND INTERACTIVE HOLOGRAPHIC INSTRUCTIONAL SUPPORT SYSTEM

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Abstract- In this paper, an interactive holographic instructional support system with intuitive control mechanism which combines 3D holographic display technology and hand-gesture recognition technology is developed. The proposed system is designed to apply in nursing instruction to enhance instructional performance. First, we scanned an instructional model of the human organ into digital 3D model and then edited the digital copy to create the corresponding 3D mesh vector. After that, the vector is projected into different perspectives to develop a suspended 3D image for holographic projection, thus to enhance instructors' and learners' sense of presence. Moreover, a special hand-gesture recognition module that enabled instructors to freely manipulate the instructional object using intuitive hand gestures is developed to allow users performing operations including perspective view change, scaling, shift, disassemble, and switch objects. It is observed that the proposed system not only effectively increased instructional convenience but also enhanced learner motivation and effectiveness. Moreover, the proposed system can be expanded into other professional disciplines as an effective holistic teaching aid.

Keywords- Teaching Aid System, Nursing Scenario-based Simulation Instruction Method, Holographic Projection Technology, Gesture Recognition Control, Augmented Reality.

I. INTRODUCTION

Healthcare is a practical discipline. Therefore, instructions primarily focus on the acquisition of clinical knowledge and skills. Student nurses are expected to associate classroom theory with clinical practice, which may be challenging due to the gap that exists between classroom theory and clinical practice. In response, nursing instructors perpetually strive to consolidate clinical experience into classroom instruction (Benner, Sutphen, Leonard, & Day, 2010). Effective instruction enables learners to internalize clinical knowledge and skills. Among the many teaching methods and technical applications used in nursing education, clinical scenario-based simulation has become an increasing popular instruction method (McAllister et al., 2013). Clinical scenario-based simulation instructions are different from conventional classroom instructions that use standardized teaching materials and structured teaching methods. Today, digital environments are a big part of learners' education and lifestyles. Nursing instructors should consider how to utilize scenario-based lesson designs to achieve their teaching objectives. The purpose of scenario-based simulations is to create life-like clinical situations. Incorporating existing technologies and techniques such as 3D simulation, virtual reality (VR), and augmented reality (AR) into nursing instruction is an inevitable trend in the future of nursing education (Carson & Harder, 2016).

The 3D graphical representations satisfy a basic human need. They provide a visual perception much closer to real life than 2D images can. Research and development involving various VR technologies stress the importance of the replication of the visual perception of the naked eye in different media. Among the various forms of graphical representation, holograms in particular maximize the 3D effect. 3D holograms provide a real-life experience unachievable with VR. They are able to portray 3D spaces on 2D planes without 3D glasses. They can even simultaneously express 3D and 4D spaces in the same image range, allowing viewers to perceive virtual objects right before their eyes. In this paper, we attempted to adopt the principles of holographic projection to create a robust 3D holographic learning system. This system projects suspended 3D images to stimulate viewers' sense of presence and bring 3D images closer to the viewer. Such images are different from the presentation of 2D images and can be used to facilitate memorization and improve learning effectiveness.

On the other hand, the human-machine interface of today's instructional systems is largely controlled using a mouse and keyboard. For humans, hand gestures are one of the most natural forms of expression. Therefore, a user-friendly and interactive teaching aid to overcome the flaws of extant teaching aids is designed. By combining gesture recognition with 3D holographic technology, we created an instructional system that can determine users' operating intentions based on the intuitive movements of their hands in the air, thereby replacing the mouse and keyboard with gestures to move, rotate, scale, and replace 3D objects on the display.

In this paper, we converted course materials into 3D models and animations. Instructors can operate and control these 3D models using intuitive hand gestures. The images were projected onto a 50-inch widescreen display for classroom demonstration. The proposed interactive naked-eye 3D graphical instructional system overcomes numerous limitations imposed by conventional 2D instructional models which could only achieve unidirectional exploration in the past. With the 3D holograms presented in the proposed system, instructors can engage in multi-user, multi-perspective exploration and use hand gestures to freely rotate, shift, and scale images in a 360° environment.

II. METHODOLOGY

2.1. 3D Object Modeling and Multi-Perspective Hologram Production

In the first, a 3D scanner was employed to scan the outer contours of the physical models to prepare the digital models for projection. Then, the digital models were retouched to enhance their details and separate the various perspectives, producing multi-perspective instructional content.It is observed that due to the material and hardware limitations, the preliminary 3D model was partially distorted or broken after scanned thus need be repaired. The Geomagic Studio was used to retouch the broken portions of the digital image, optimize the scanned data, reduce noise, eliminate overlay, and edit image polygons to produce the finished model as shown in Figure 1-3

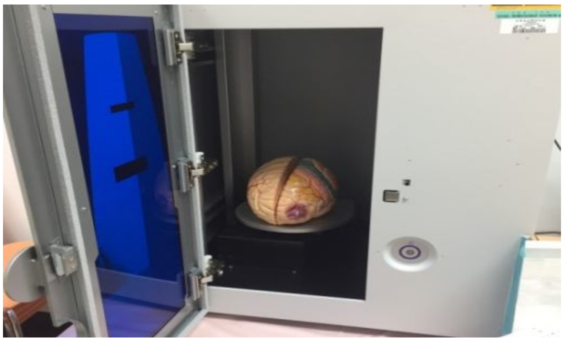

Figure 1. Instructional Object: 3D Scanning of a Human Brain Model

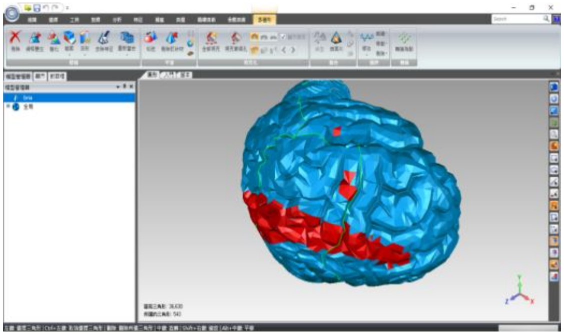

Figure 2. Retouching

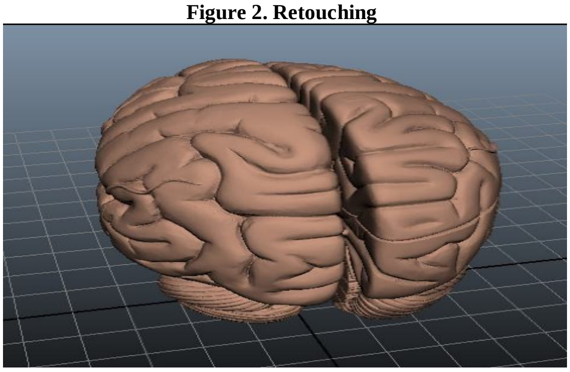

Figure 3. Instructional Object: 3D Model of the Human Brain

2.2. Holographic Display Platform Design

A multi-perspective projection system to project the instructional object realistically is developed to project 2D objects into a 3D space to produce the holographic display of the object. Holography, or holographic projection, is an imaging technique that records all the information (amplitude and phase) of the reflected (transmitted) light waves when an object is imaged. The different angles of the image can be displayed using images taken from different angles or perspectives, creating the illusion of a 3D object. Unlike conventional 3D display techniques, holographic images can be viewed without 3D glasses, which is not only convenient for viewers but also reduces cost. In addition, 3D images can be presented to an audience from different perspectives, enhancing intuitiveness.

However, recording and reconstructing information can be costly, making it difficult to build holographic display systems repeatedly. In this study, we adopted virtual holographic projection technology to overcome this obstacle. Virtual holographic projection uses a highly reflective polyhedron to construct 3D structures, layering 2D images into a 3D model. The surface of the holographic projection system was coated with a high-performance, double-sided projection film. Vacuum magnetron sputtering was adopted to coat the surface of the film with a Nano-grade, photosensitive layer to achieve a transmittance rate of 99.99% while maintaining superior reflectivity (a mirror-like appearance). To maximize display performance, the ideal reflective material and construction angle are selectedthrough theoretical inferences and repeated testing. These parameters were used to produce a holographic pyramidal structure that was compatible with a 50-inch display.

2.3. Gesture Recognition and Control

Rapid and accurate detection of hand gestures in different environments is a key objective in designing a responsive gesture recognition system. The system must be able to track hand movements before it can successfully detect hand features, identify patterns, and ultimately analyze control instructions. In this paper the Leap Motion module is adopted in hand-gesture control. We used the Unity SDK to write a control program for the Leap Motion sensor thus the gesture control function is incorporated into the projection platform to control the holographic images.The Leap Motion sensor uses an infrared LED and a grey-scale camera to detect motion and generate 3D data, reconstructing hand motions in a real-time 3D environment. The detection range is between 25 and 600 mm above the sensor in an inverted pyramid shape. During application, the Leap Motion sensor periodically transmits hand motion information. Each packet includes a palm list and palm information, as well as a finger list and finger information. The sensor then analyzes the changes in the data to determine the intention of the user, thereby achieving system control. In other words, the system processes the hand features detected by the Leap Motion sensor to track the position, angle, direction, and finger locations of the hand in a 3D environment as shown in figure 4. This information is then analyzed to determine gestures. The gesture recognition system developed in this paper can detect two types of gestures, namely, control gestures and continuous movement. Control gestures refer to the comparison of hand features against pre-established hand features. When a pre-established gesture is detected, a corresponding value is calculated and given, such as the distance between two hands. Continuous motion is the detection of hand movement trajectory from a series of images. The movement is then compared to prerecorded hand movement samples to determine the nature of the movement. Once the movement is analyzed, the system converts it into a control instruction for the 3D object.

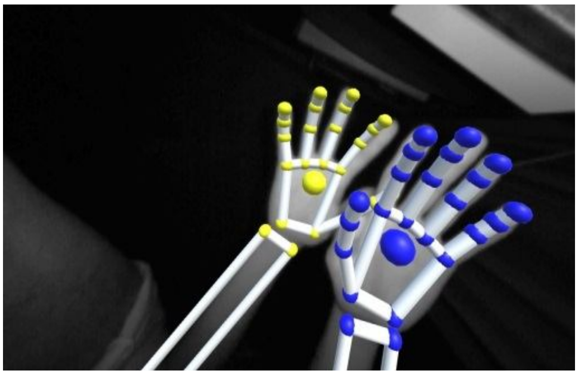

Figure 4. Hand Features Detected by Leap Motion

III. EXPERIMENTAL RESULTS

The main framework of the proposed teaching aid is complete as shown in figure 5. We are now in the testing and revision stages. The function demonstrations of the teaching aid prototype are illustrated in Figs. 6-7. In addition to gesture control, we aim to sequentially add new functionalities to the system to facilitate instruction and gradually convert existing physical instructional models into digital 3D models, thereby enriching system content and gradually phasing out physical instructional models.

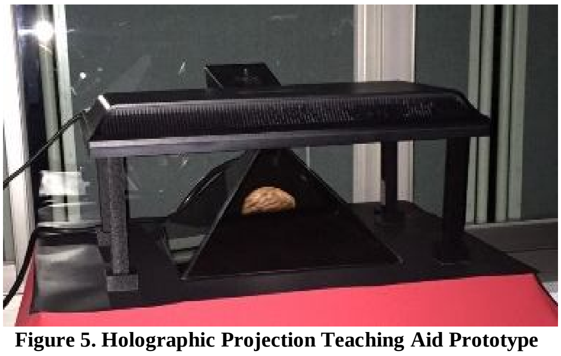

Figure 5. Holographic Projection Teaching Aid Prototype

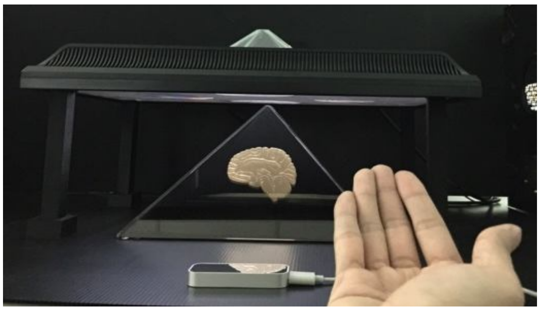

Figure 6. Gesture Control: Switching Perspectives

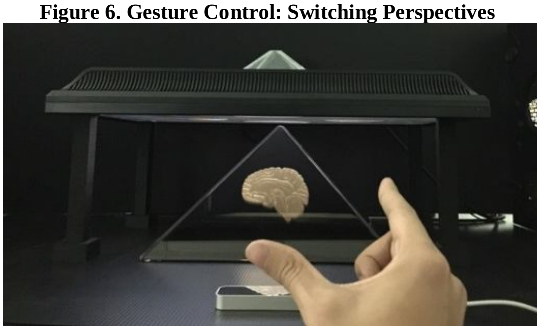

Figure 7. Gesture Control: Scaling

CONCLUSION

Nursing scenario-based simulation is an instructional method that can replicate practical clinical situations in a safe environment to facilitate learning and prepare learners for real life clinical situations. Situated learning is characterized as learning in real-life or simulated environments, wherein learners are able to apply knowledge to clinical practice through situational interactions. It is essentially a type of experiential learning that effectively changes learner beliefs and attitudes. Therefore, situated learning is particularly important in nursing education.

Taking into account the various limitations of physical instruction in nursing education, the purpose of this paper is to design a 3D holographic projection platform with gesture recognition capabilities to serve as a classroom teaching aid. The system enables instructors to use intuitive hand gestures to control the content and form (scaling, shifting, angle switching, and disassembling) of pre-modeled 3D objects. By creating digital 3D content, instructors can rapidly exchange, share, revise, change, add, and associate instructional content, thereby achieving a dynamic functional display. The holographic platform allows multi-user, multi-perspective viewing of a virtual object, which is ideal for classroom applications. In addition, the light-shadow presentation and responsive interactive framework of 3D projections help to stimulate learner motivation and interest, thereby enhancing learning effectiveness.In the future, we hope to migrate physiological dynamics instruction, including blood circulation processes, respiratory and digestive processes, and brain operation processes, into the system. We anticipate that the system will provide more systemized and active instructional content that learners find interesting, ultimately enhancing learning effectiveness. Finally, the proposed instructional support system can easily be expanded into other professional disciplines to become an essential teaching aid for instructors specializing in a variety of fields.

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