Virtual Reality Wound Care Training for Clinical Nursing Education: An Initial User Study

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ABSTRACT

Wound care is an essential nursing competency, where dressing change is an important component. Compliance with aseptic procedures and techniques is necessary to reduce the risk of infection. Proficiency in the skills can be developed through adequate practice. In this paper, use of virtual reality is proposed to provide more practice opportunity. An immersive virtual environment is developed to simulate the steps of changing a simple wound dressing. Positive comments are obtained from an initial user study on usability with an experienced nurse and an undergraduate nursing student. Comprehensive evaluation will be conducted to further improve the simulation.

Keywords: Virtual reality, wound care, dressing change, nursing education.

Index Terms: I.3.8 [Computer Graphics]: Applications; I.6.3 [Simulation and Modeling]: Applications; J.3 [Life and Medical Sciences]—Health; K.3.1 [Computers and Education]: Computer Uses in Education—Computer-assisted instruction

1 INTRODUCTION

Nursing involves many clinical skills which require manual dexterity. Adequate practice is necessary to acquire the skills, develop proficiency and reduce errors. Virtual reality (VR) technology, well-known for its benefits for training, has potential to offer alternative approaches to increase practice opportunity. For example, VR has been applied for the training of cardiopulmonary resuscitation during emergency situations [6], urinary catheterization [7] and nasogastric tube placement [1]. In wound care, changing wound dressing is an essential skill where the steps should be carried out properly to ensure aseptic processing. The training is conventionally delivered through lecture and video demonstration, and also through simulation using rubber mannequin with real dressing equipment and materials applied. Nevertheless, up to now, VR is largely adopted as a means for pain distraction during the process of wound care [4]. Recently, an online simulator is developed for learning decision-making skills in wound care, where augmented reality technology and tablets are used to facilitate observation and analysis in the training [5]. In this paper, the application of VR for wound dressing training is presented. The steps of changing a simple wound dressing are simulated for learning the cognitive and manual skills and the proper aseptic techniques.

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2 METHODS

To realize the proposed idea, the first step is to gain understanding about wound care and the procedures of changing a wound dressing by making reference to relevant texts and instructional videos, and also by consulting clinical experts regarding the procedures and the techniques in real practice as well as the training approaches. Next, the scope of the simulation, the level of details and the complexity are determined depending on the resources available and the technical limitations of VR technology. Iterative development cycle then proceeds, where comments from clinical experts are sought to continuously improve the design and the system.

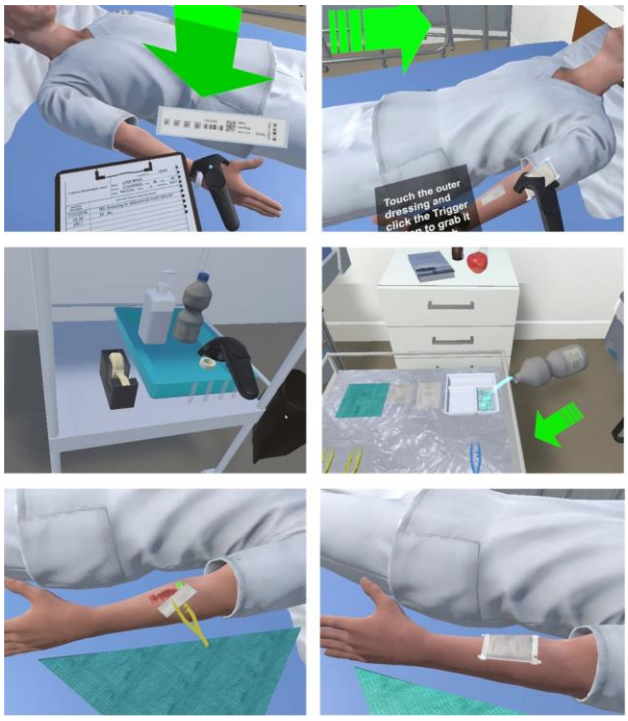

Figure 1: Virtual scenarios of wound dressing change.

2.1 Hardware and Software

The proposed VR training system is developed with Unity Pro, a cross-platform game engine. The hardware adopted in this study is the HTC VIVE VR system. It provides a pair of controllers that can produce vibrotactile haptic feedback. Each controller is equipped with a multifunction trackpad, grip buttons, dual-stage trigger, system button and a menu button. In this study, the trigger is only used to simplify the usage and virtual manipulation, so that trainees can focus on the simulated procedures and the virtual content. The hands of the user are emulated with the pair of controllers in the virtual environment.

2.2 Procedure of Changing Wound Dressing

The principles of wound dressing techniques are to maintain asepsis throughout the process and minimize exposure of the wound, and to ensure proper hand decontamination and effective application of aseptic techniques, where patient comfort is also essential in the process [2]. The dressing procedures includes the removal of old dressing, wound cleansing, application of new dressing, and post-dressing processing, i.e., clean-up, documentation and follow-up [3]. In this study, the steps involved in changing a simple wound dressing are only concerned, whereas preparatory steps in performing hand hygiene and putting on gloves are not included. The simulated procedures are divided into five stages, namely, patient preparation and inspection, equipment and materials preparation, sterile field preparation, wound cleansing, and finally, new dressing application and clean-up. The setting and environment, the maneuvers as well as the interactions in each step, are simulated in fine details with immersive VR, as illustrated with the snapshots shown in Fig. 1. Visual cues such as pop-up texts attached to the controllers (invoked on-demand by users by pressing the menu button), green arrows and flashing objects are provided interactively to guide the user.

3 Initial User Study

The steps of changing a small wound dressing as described in the previous section are simulated using the HTC VIVE VR system. An initial user study on the usability of the system is evaluated with an experienced registered nurse and an undergraduate student who have already learned how to change wound dressing from a conventional nursing therapeutics subject. They can complete the virtual procedures within 15 minutes and are generally positive toward the use of VR for learning the procedures. Their after-use comments will be discussed in detail in the next section.

4 Discussion

Feedback from the users indicates that the virtual training is interesting and helpful. Compared to watching training videos, which is an approach commonly used for teaching clinical skills, the proposed virtual training simulator is more realistic, interactive and engaging. It is superior to instructional videos in providing better experiences through the virtual hands-on practice. The users agree that that the system can simulate the essential steps in changing wound dressing and can potentially speed up the learning curve of the procedures in real settings.

Although it is commented that the immersive virtual environment and simulation are realistic, the current prototype system is limited in several aspects. First, the HTC VIVE controllers cannot simulate subtle maneuvers that can be made by hands in reality. The interactions simulated are thus simplified to adapt to the limited maneuverability of the controllers. Hence, the VR training is more capable of providing a cognitive walkthrough for procedural training, rather than aiming to improve clinical dexterity in performing the manual skills.

Associated with this limitation are issues due to counter-intuitive manipulations. For example, the action of using a pair of forceps to hold an object in reality by exerting pressure with the thumb and index finger on the forceps is simplified. It is only emulated in VR by pulling and holding the trigger button of the controller. It is observed that users are confused between the real and the emulated actions. Some explanation and practice are required to adapt to the latter action in the virtual environment.

Besides, the proximity threshold for detecting collisions among objects in virtual environments is set too tight in some cases, making it difficult for users to pick up objects or to put them at targeted positions. For example, it is necessary to move the strips of adhesive surgical tape close enough to the edge of the gauze so that the simulator could recognize it as the action of fixing the edge onto the skin with the tape. The over-stringent proximity checking leads to the need of multiple attempts to complete the tasks, thus making the interactions counter intuitive and causing user frustration.

In the virtual training, haptic cues and feedback are only produced by the vibration generated by the controllers. Other than such vibrations, realistic tactile feeling arising from virtual interactions is not available. Users are like “playing with air” in the virtual process of changing a wound dressing, despite the realistic visual feedback produced by the simulator. The limitation is due to unavailability of realistic hardware user interface, which affects not only the rendering of realistic haptic sensation in virtual environment, but also the subtlety of maneuvers that can be simulated.

5 Conclusion

The paper presents the application of VR technology to simulate the steps of changing a simple wound dressing in immersive virtual environment for the purpose of wound care training. Visual cues and texts are provided interactively as guidance. Attributed to the benefits that the simulation is virtual and autonomous, the proposed system can facilitate self-learning at own pace while saving the cost of wound dressing materials. While efforts have been made to simulate fine details and subtle maneuvers in the dressing process that are critical for aseptic processing, further research will be conducted to enhance simulation accuracy and realism by gaining in-depth understanding of the procedures from nursing experts, and through improvement in user interface devices and interaction approaches (e.g. data gloves, vision-based or infrared proximity sensing methods). Comprehensive evaluation will be carried out to assess the usability of the proposed wound dressing training simulator and its training effectiveness, i.e. the transfer of virtual learning experience into real practice.

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