https://doi.org/10.2352/ISSN.2470-1173.2021.13.ERVR-178

Virtual Reality Instructional (VRI) module for Training and Patient Safety

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Abstract

Healthcare practitioners, social workers, and care coordinators must work together seamlessly, safely and efficiently. Within the context of the COVID-19 pandemic, understanding relevant evidence-based and best practices as well as identification of barriers and facilitators of care for vulnerable populations are of crucial importance. A current gap exists in the lack of specific training for these specialized personnel to facilitate care for socially vulnerable populations, particularly racial and ethnic minorities. With continuing advancements in technology, VR based training incorporates real-life experience and creates a "sense of presence" in the environment. Furthermore, immersive virtual environments offer considerable advantages over traditional training exercises such as reduction in the time and cost for different what-if scenarios and opportunities for more frequent practice. This paper proposes the development of Virtual Reality Instructional (VRI) training modules geared for COVID-19 testing. The VRI modules are developed for immersive, non-immersive, and mobile environment. This paper describes the development and testing of the VRI module using the Unity gaming engine. These VRI modules are developed to help increase safety preparedness and mitigate the social distancing related risks for safety management.

1. Introduction

Good communication between the patient and the health care providers is the key for patient safety and happiness. Sometimes health care providers can struggle to provide urgent attention when needed due to certain racial and ethnic minorities, particularly in rural areas or where socially vulnerable populations exist. Virtual Reality aims to combine human senses such as hearing, touch and sight, with software and hardware to create an immersive exploratory virtual environment [1]. Accessing Virtual Reality Instructional (VRI) training modules, the complete integrated care team can ensure meaningful understanding for all patients. These trainings can help healthcare organizations to shrink training and education budgets. The trainings provided by the VRI can be easily conducted by the health care staff in multiple sessions over the course of the medical encounter. This can prepare the workforce for changing patient demographics, technology and data analysis and multigenerational workforce integration, among others No training or safety module is too short to use the VRI. With the recent advancements in the medical field most of the training has been moved to virtual especially during COVID-19 pandemic. Virtual reality can help in elevating the teaching and learning experience for patients and integrated care team to a whole new different level. Virtual reality provides a new way to train different medical groups any number of times.

COVID-19 has governments at all levels operating in a context of radical uncertainty. The regional and local impact of the COVID-19 crisis is highly heterogeneous, with significant implications for crisis management and policy responses [2]. While viruses are immune to considerations of race or class, COVID-19's impact has been greatest upon certain vulnerable groups. In the context of clinical trials, vulnerability has often been seen as a reason to exclude groups from research. However, such protectively intended measures can, in some cases, result in injustice, both in who is permitted to participate in studies and in who benefits from the resultant knowledge [3]. As the COVID-19 pandemic continues unabated, socially vulnerable populations face disproportionate risks as is often the case during public health emergencies. Emerging trends of differential impact on socially vulnerable populations, such as certain racial and ethnic minorities, among others, require urgent attention to improve quality of care and patient safety.

Figure 1. View of drive thru COVID-19 Virtual Reality Instructional (VRI) training module

The immersive, non-immersive, and mobile environment are developed and implemented in Unity 3D to train integrated care team members more safely and efficiently. Figure 1 shows our developed non-immersive environment of VRI module for training and patient safety. The VRI modules are designed to provide a real life like environment for training and patient safety. These modules not only provide a safer alternative to an in-person training for the ongoing COVID-19 pandemic but also helps in reducing the cost and time involved in training the people in-person. The training modules developed are based on the findings from various patient studies to improve the patient safety for most vulnerable populations of COVID-19 pandemic. The VRI modules are designed based on the analysis of the cases handled for the most vulnerable people in the current COVID-19 situation. Our modules are interactive and focus on the trainings that can ensure a better work experience of the integrated team members. The experience will be similar to an in-person training with socially distancing from vulnerable populations and yet achieving the main training and safety goal.

Day to day life activities has been affected, due to COVID 19 outbreak. Following social distance has become a big problem. It is a drastic change in every one's lifestyle, especially in hospitals. Due to COVID 19, there are more patients visiting hospital. It has become a big challenge to practice social distancing in hospital activities. As a solution for this problem, this paper suggests training hospital staff and patients with the help of VRI modules. As a result, users will get a habit of following social distancing. The rest of the paper is structured as follows. Section II briefly describes the related work for VRI modules. Section III describes the implementation of the CVE in three phases. Section IV presents the simulation and results of the user study. Section IV discusses the drawn conclusions and proposed future work. Finally, Section V states acknowledgments.

2. Related Work

Virtual reality instructional modules are engaging and motivating for students as they provide hands-on experience [4,5]. Educational software helps students learn concepts by applying theory to real-world examples. Sharma et al. [6, 7] have developed and evaluated the Game–Theme Based Instructional (GTI) modules for teaching computer science student's concepts to the students. The GTI modules and VRI are designed to teach the concepts of object-oriented programming, binary tree, linked list by using interactive, graphical, game-like examples [8-10]. VRI modules have also been developed to teach arrays and loops to computer science students [11]. Clark et al. [12] have used modular education in games by providing a framework that is capable of entertaining students as well as offering a natural, effectively adaptable path for instructors.

Game-based learning (GBL) is a learning paradigm where learning objectives are combined with game elements to make the learning process more enjoyable and engaging for the students. Lin et al [13] have created a game based learning (GBL) application to help students learn English words. The application aims to increase students' motivation to learn English words and to facilitate the development of a curriculum to learn English words. On the other hand, Li et al [14] have developed a GBL module to learn the Chinese language by going on several missions divided stages using gaming metaphor. Wang et al [15] have also developed an educational game helping Taiwanese students type in English language.

Sharma et al. [16] have incorporated immersive VRI modules as a training and education tool for emergency response. They have conducted virtual emergency evauation drills for an aircraft evacuation [17], a building evacuation [18], a subway evacuation [19], a university campus evacuation [20] and a megacity evacuation [21] disaster preparedness and emergency response training. Medical Simulation creates opportunities for learners to identify, practice and evaluate situational awareness (SA) during various clinical events. Healthcare Simulation is particularly useful when those events are rarely encountered during training or routine clinical practice. Medical errors associated with lack of attention, inappropriate interpretation of data and lack of follow up to surrounding activities and equipment are not uncommon.

3. Implementation of VRI Module

The proposed VRI module was designed using 3DS Max, Sketch Up and programmed with a Unity 3D gaming platform. The VRI module was developed for immersive, non-immersive, and mobile environments. In non-immersive environment participants are able to navigate in the environment using a desktop computer, mouse, and keyboard. On the other hand, in the immersive environment, the participants wear an Oculus Rift S head-mounted display and interact the environment using Oculus rift controllers. In mobile environment, the users are able to use the touch controllers on the smart phone/tablet to navigate inside the environment. Figure 2 shows the detailed flow chart of the implementation:

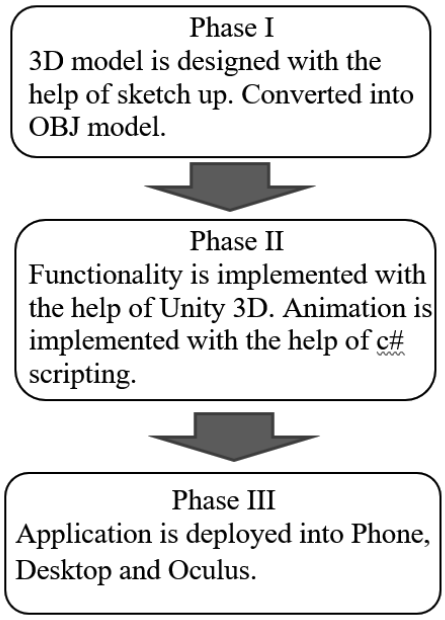

Figure 2.A flow chart showing different phases for implementation

The implementation of the VRI module was done in three phases:

3.1 Phase 1: Modeling

Phase 1 of the VRI module consisted of modeling the hospital building and surrounding buildings using 3Ds max, and google sketch up. The environment was modeled to scale and imported real-time textures. The environment included adding 3D models of furniture in hospital rooms, labs and halls such as tables, computers, mouse keyboard, etc. In parking lot there are two tents modelled for COVID 19 testing spots. Parking lots also has provision for parking cars in specific parking spots. Along with the road, footpath is implemented to practice six feet distance while walking. Waiting chairs are implemented near tents with proper social distance. Once the development of the 3D model was finalized, the whole model was exported in ".obj" format. This format was exported to Unity 3D gaming engine.

3.2 Phase 2: Exporting to Unity 3D and Animation

In phase 2, the modelled environment was exported from Google Sketch-to Unity 3D gaming engine. Initially, Unity 3D's tools for animating avatars were utilized to give each agent in the environment functionalities necessary to navigate in the environment. These functionalities included walking, running, and jumping. In addition, C# scripts were added to the user-controlled agents in order to give users the ability to communicate with the menu and laser pointer for selection as shown in figure 2. This application's main purpose is to train medical staff and patients on how to follow the COVID 19 protocols. As a part of this

functionality implementation, hospital staff characters are modelled with a full suite on. The agents depicting staff are animated in the environment with certain measures to indicate social distancing. Two tents are implemented next to the hospital to serve as a preliminary testing center.

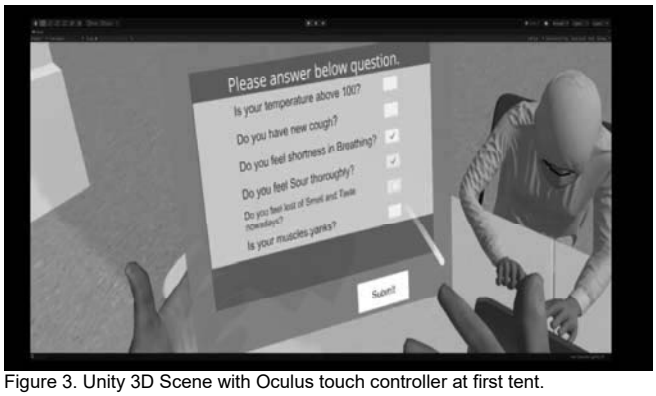

Figure 3. Unity 3D Scene with Oculus touch controller at first tent.

The first tent was implemented near the hospital's incoming traffic so that everyone who is trying to access the hospital will undergo a preliminary test and survey. This tent serves for both pedestrians and drive through people. At this tent when a user approaches temperature is taken with the help of an infrared thermometer. Along with that a set of questions are gathered from world health guidelines. These questions are asked to identify any symptoms of COVID 19 as shown in figure 3. If the user answers yes to any of the questions, the user is asked to proceed to the next tent where further examination will be done. The questions are as follows:

- Is your temperature above 100?
- Do you have a new cough?
- Do you feel shortness in Breathing?
- Do you feel Sour thoroughly?
- Do you feel loss of Smell and Taste nowadays?
- Do your muscles yank?

The second tent is placed at the same street towards the parking lot, so that user can proceed to the next tent comfortably. In this tent, the user undergoes the swab test. Once the user reaches the second tent, a trained doctor with the mask on approaches the patient and does the swab test through the nose. Once the swab test is done, the user is instructed to answer the question," Are you having a breathing problem?". If the user is having a critical state of breathing problem, he/she is instructed to enter the hospital through the back door. If the patients do not have a breathing problem, they are asked to enter the hospital through the front door.

3.3 Phase 3: Deployment to devices: Oculus integration and controller hand simulation

In phase 3 C# scripts were developed to integrate Oculus Rift S and the Oculus Touch controllers in the environment. The users were able to navigate in the environment and interact with objects and menus using oculus touch controllers. The Oculus Touch headset allows the users to navigate and experience the environment with full immersion. Oculus Touch controllers also give haptic feedback to the user when using objects such as guns and selection laser pointer as shown in figure 4. In this phase, the deployment into multiple devices is done. To make this application available for all audiences, the application is deployed into multiple devices mobile, desktop, and oculus. Mobile and desktop versions give access to a larger audience, and oculus gives an immersive feeling.

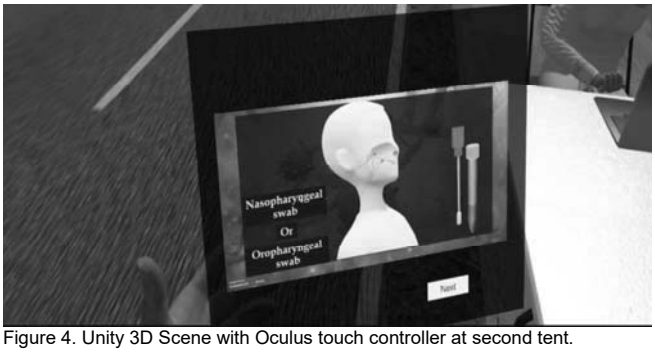

Figure 4. Unity 3D Scene with Oculus touch controller at second tent.

In the final phase, the application was deployed into multiple devices. As all the users may not have access to Oculus hardware, other devices such a mobile, tablet, desktop were used to reach wider audiences. Having an easily accessible devices make it easier to access the VRI training module. The whole lifecycle of the project is shown in figure 5.

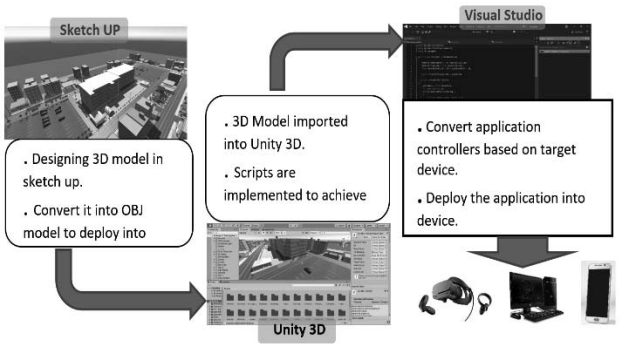

Figure 5. The life cycle of the project

4. Simulation and Results

The objective of this work was to develop a VRI module that serves as a platform for COVID-19 protocols training of hospital staff and patients. In the immersive VRI module, the two oculus controllers are used to navigate in the environment. The immersive VRI module is shown in figure 3 and figure 4. Whereas in non-immersive VRI module, the user is able to navigate in the environment using a desktop computer, mouse, and keyboard. The non-immersive VRI module is shown in figure 6.

Figure 6. Non-immersive VRI module for pedestrian walkthrough

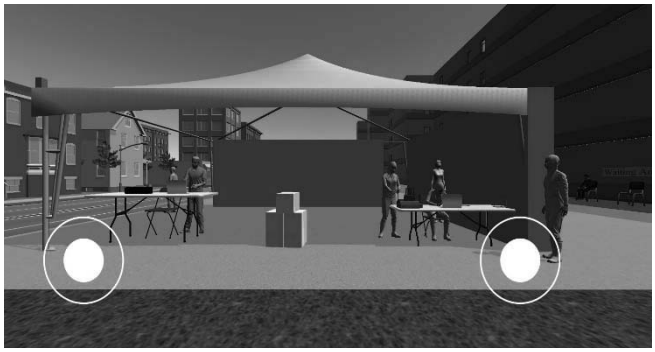

Figure 7. Mobile VRI module for pedestrian walkthrough

For the non-immersive VRI module or desktop VRI module, the keyboard is the controller, to interact with the environment. On the other hand, in mobile VRI module, the touch screen is the most commonly used for interacting in the environment. As a result, two navigational controller touch buttons are implemented to move around in the environment as shown in figure 7.

Figure 8. Immersive VRI module for pedestrian walkthrough showing panel attached to left hand.

The user is able to use the laser pointer triggered through the oculus touch controllers for interacting with the menus in the immersive VRI module. As shown in figure 3, earlier the user is able to use the laser pointer to click the check boxes for questions asked on the questionnaire. The questionnaire panel is attached to the left oculus controller and the laser is assigned to the right hand oculus controller as shown in figure 8. All the three VRI modules (immersive, non-immersive, and mobile environment) are able to simulate pedestrian walkthrough or drive in walkthrough. The VRI modules also have provision to use a car for driving to the tent for COVID testing.

5. Conclusions

Our proposed VRI module can be used for training hospital staff as well as to conduct COVID -19 testing training for patients who need to be tested. We have presented a hybrid (human-artificial) platform where experiments for patient safety and quality of care can be conducted using computer controlled (AI) agents and user-controlled agents. We hope our proposed VRI module will help in conducting training for patient safety and what-if scenarios that are difficult to model in real life. The developed VRI modules can also act as a training and educational tool for decision-making strategies. The user-controlled agents were able to enter the immersive environment using Oculus Rift S and were able to respond to COVID testing training protocol. This platform can be fully immersive with the use of Oculus rift and Touch, controllers or non-immersive desktop version with the use of mouse and keyboard or mobile version with touch buttons. The VRI modules are developed for immersive, non-immersive, and mobile environment. This project aims to characterize determinants for improving quality of care and patient safety among vulnerable populations, specifically with a focus on racial and ethnic minorities, and fully incorporate these findings into the creation and development of Virtual Reality Instructional (VRI) training modules geared for integrated care teams to enhance care delivery. In conclusion, this COVID testing VRI module can act as a training platform that allows hospital staff and doctors to follow protocol and engage with patients from vulnerable populations safely and efficiently.

Acknowledgments

This work is funded in part by the NSF award #1923986, NSF Award number 2032344, and NSF Award Number: 2026412.

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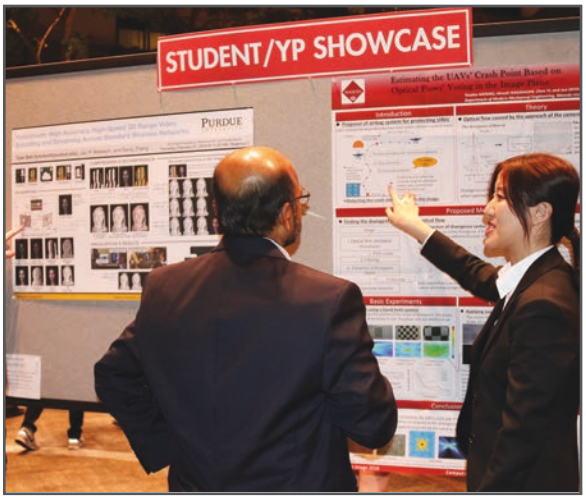

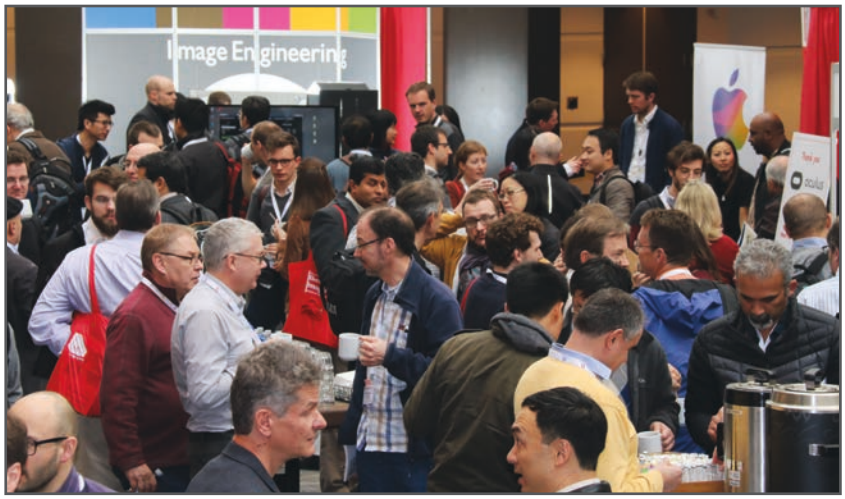

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