Design of Visual Deficit Simulation for Integration into a Geriatric Physical Diagnosis Course

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ABSTRACT

One major challenge in the field of medical education is teaching students to empathize with patients. To help address this need, we have designed a system in virtual reality (VR) that can simulate macular degeneration and that requires medical students to carry out a self-medication task from the perspective of a patient. The simulation includes a home environment, interactive medication bottles and pills, reading requirement, task list, and completion goals. In contrast with prior work, this simulation is designed for direct integration into a university level physical diagnosis course. Design considerations for practical use and measurement of empathy in a large scale, time-constrained environment are also discussed.

Index Terms: Human-centered computing—Visualization—Visualization design and evaluation methods

1 Introduction and Prior Work

The simulation of eye diseases using virtual reality is a relatively well explored topic. For example, Ai et al. have proposed the use of VR for simulating macular degeneration as early as 2000 [1]. Jin et al. extended this work by more accurately applying scotoma and visual effects to represent deficits [4]. Such simulations have also been used to improve empathy. For example, Häkkilä et al. created a simulation and presented it to a number of design students for evaluation [3]. Results showed that the simulation improved subjective responses compared to screenshots alone. Even more recently, Ates et al. came up with a video see-through version of deficit simulation [2]. They even went so far as to simulate macular degeneration, diabetic retinopathy, glaucoma, cataracts, color blindness (protanopia), and diplopia. However, these simulations were all either simply made for demonstration purposes, held in controlled or experimental settings, or were not suited to practical use in medical coursework.

In order to adapt these types of simulations for practical use, we implemented a more interactive patient simulation and tested it with medical students, fellows, and educational staff. From information gathering and discussion following an initial prototype, we discovered that due to the short nature of coursework and high rotation of student learners, the simulation had to simulate everyday tasks to establish familiarity, yet be concise to be deployed in a classroom or learning setting. To address this, our simulation incorporates a task that is both a common everyday activity and also requires fine motor control to better represent real life patient tasks.

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Figure 1: Images showing an overview of the simulation scene (upper left), a medical student using the display (upper right), the training scene with a blank pill bottle for instruction (lower left), and a peripheral view of the labelled pill bottles taken with the macular degeneration on (lower right).

2 Environment and Self-Medication Tasks

Our system was implemented with Unity 3D and the HTC Vive. The user interacts by using any of the controllers to depress a start button that activates macular degeneration and enables interaction with medications in the scene as shown in Figure 1. The visual deficit is imposed on the scene during the simulation.

2.1 Tasks and Setup

In general, the simulation is designed to replicate a time-constrained self-medication task. This allows participants to 1) become familiar with the environment, 2) understand macular degeneration, and 3) develop empathy for geriatric patients, all in a matter of minutes. This design is beneficial for classes with large groups that have to undergo training in a short period of time with limited space or resources.

2.2 Training

When the scene is loaded, the user is given a training scene in order to assist them with familiarization of the virtual reality system and its controls. Users are provided with a medication bottle with which he or she can practice interaction. When user is ready to start the self-medication task and exit the training scene, he or she will use one of the controllers to press a button, shown as the large cube in the lower left of Figure 1 on the table.

2.3 Self-medication

The next scene is loaded with macular degeneration turned on. Tasks are displayed on a TV monitor, and include the entire process of self-medication from start to finish. The user is required to complete all the tasks within 60 seconds to successfully complete the simulation. Tasks must be completed in sequentially order, and those that are completed are marked with green check marks during the simulation. If all tasks are accomplished, a blue "Done" message is displayed on the TV.

Tasks not completed in time are marked with a red cross after the 60-second window is over. Users who took the wrong medication (any pill that is not a blood pressure reducer) will prematurely fail to complete the simulation even if he or she still had time left. When the simulation is over, the macular degeneration is turned off, and the user is given 10 seconds to view the task failure. After that, the simulation is reloaded to the training scene for the next participant.

2.3.1 Medication Selection

There will be three medicine bottles present after the training scene, including a blood pressure reducer (lisinopril), anticoagulant (Warfarin), and diabetes medication (Metformin). The user is instructed via the screen to first pick up the blood pressure reducer bottle. Because the participant might select multiple bottles, this task is not checked until user attempts to open the cap of the bottle. This enforces that the user will need to read the labels of the medicine bottles to identify the correct bottle.

2.3.2 Cap Removal

The user must then open the cap of the bottle by aligning the fingers of one hand with the cap of the bottle held in the other and pressing the trigger on the controller. This holding and removal task is designed to replicate fine motor coordination that is often more difficult in aged populations. When the cap of the correct bottle is taken off, the tasks of "Pick up lisinopril bottle" and "Open cap" will be checked simultaneously.

2.3.3 Dispensing

After opening the cap of the bottle, user can retrieve the pills inside the bottle by shaking the bottle in an upside-down position using the controller. User will then grab one pill on the table by pressing the trigger on the controller to pick up the tablet. The task "Drop pills on table and grab a pill" will be checked when user picks up the correct pill. Keep in mind, this task will not be completed until user already picked up and opened the cap of the correct bottle.

2.3.4 Fluid and Medication Intake

With the correct pill in one controller, user will use the other controller to pick up the mug by pressing the trigger on that controller. The task "Pick up mug" will be checked when user picks up the mug and previous required tasks are checked.

When user has the correct pill held in one controller and a mug in the other controller, the user is then required to bring both objects near headset to simulate the act of taking the medication and drinking water. The task "Bring pill and mug to mouth" will be checked after user completes this act and other tasks previously mentioned are checked. As mentioned before, if user completes all required tasks within the 60-second window, a message "Done!" appears on the TV. If user fails any other task due to running out of time or taking the wrong pill, red cross mark(s) is/are displayed to inform the user that he or she did not complete the mission.

3 Pilot Testing and Design Considerations

To gather feedback on the usability of our simulation in an actual classroom setting, three 4th year medical students, several Rheumatology fellows, and education staff were able to demo the VR visual defect simulation at various intervals of development. Most participants felt that the simulation was easy to use and applicable to real life practice. Some other feedback included some changes in clarity of the prescription bottles, need for instruction table on how to proceed with the task (which was later added based on this feedback), feedback on more realistic visuals of macular degeneration, addition of task completion list to allow the participant to realize the difficulty of the various tasks. These feedback items were incorporated by the team and included in this simulation.

Figure 2: Images of the task list for patient instructions, showing a failure case (left) and successful completion (right).

4 Audience Interaction

The conference audience will be able to interact with this demonstration as if they were a medical student going through the phsyical diagnosis course. Participants will first go through the training phase to become familiar with the environment and interact with an empty (blank) pill bottle. Next, the macular degeneration and medication task will begin, asking them to take a medication from the perspective of a patient. The demo should convey some of the difficulties experienced by geriatric patients in everyday life.

5 Conclusion

In this research demo, we present a simulation of self-medication with advanced macular degeneration. The application includes fine motor control tasks designed for a fast paced physical diagnosis course, making this simulation practical for classroom use. We hope that this work will help students, physicians, and lay people develop empathy for patients or elderly individuals with visual handicaps.

6 Video Link

A link to the video showing basic interaction can be found below. Turn on YouTube captions to view video annotations. https://youtu.be/erPNBl8pNDw

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References

[1] Z. Ai, B. K. Gupta, M. Rasmussen, Y. J. Lin, F. Dech, W. Panko, and J. C. Silverstein. Simulation of eye diseases in a virtual environment. In *Proceedings of the 33rd Annual Hawaii International Conference on System Sciences*, pp. 5–pp. IEEE, 2000.

[2] H. C. Ates, A. Fiannaca, and E. Folmer. Immersive simulation of visual impairments using a wearable see-through display. In *Proceedings of the Ninth International Conference on Tangible, Embedded, and Embodied Interaction*, pp. 225–228. ACM, 2015.

[3] J. Häkkilä, A. Colley, J. Väyrynen, and A.-J. Yliharju. Introducing virtual reality technologies to design education. In *Seminar. net*, vol. 14, pp. 1–12, 2018.

[4] B. Jin, Z. Ai, and M. Rasmussen. Simulation of eye disease in virtual reality. In *2005 IEEE Engineering in Medicine and Biology 27th Annual Conference*, pp. 5128–5131. IEEE, 2006.