PulmonaReality: Transforming Pediatric Pulmonary Function Experience Using Virtual Reality

Andrew Jacobson, Jinsil Hwaryoung Seo*
Soft Interaction Lab, Department of Visualization
Texas A&M University

Figure 1: Screen Shots of *PulmonaReality*'s *Sailboat and Birthday Scenes*

Abstract

This paper presents PulmonaReality, an interactive virtual reality game aimed at young patients to help immerse them into a world that makes pulmonary function tests more enjoyable for the user while providing more reliable results for the examiner. Computer games designed to work with medical tests have been shown to have potential. While there are existing games out there, they are beginning to show their age in comparison to many games played by modern-day patients. The design of our project focuses on usability and enjoyment for young children. In our preliminary user studies, children reported that the system was easy to use with minimal instruction and evoked a sense of wonder when they experienced our different interactive 3D environments.

Keywords: Virtual reality; pulmonary function test; young children; immersive; video game

Concepts: • **Software and its engineering~ Virtual Worlds;** *Interactive Games*

1 Introduction/Background

The idea we chose to produce was PulmonaReality, a VR interactive experience that was designed for children required to perform pulmonary function tests. These tests are required for all ages to examine lung performance in terms of volume and airflow. The machines used for these assessments are sometimes intimidating for young children, and this has been known to cause issues during examinations. We aim to ease the process for this demographic, making it both more enjoyable for the user and reliable for the tester.

*hwaryoung@tamu.edu

SIGGRAPH '16 Posters, July 24-28, 2016, Anaheim, CA,
ACM 978-1-4503-4371-8/16/07.
http://dx.doi.org/10.1145/2945078.2945164

1.1 Pulmonary Function Tests (PFTs)

Our initial research into the subject revealed some interesting findings. We began by reviewing how pulmonary function tests (PFT) are performed and operate, looking at some of the common the challenges involved in performing the examination on young children. The test, called spirometry, involves the patient breathing in a deep breath and blowing into a mouthpiece which is wired to a spirometer that calculates precisely the volume and rate of air flow in the patient's lungs and airways [Seed, et al. 2010]. It requires full effort from the patient to be effective. Aside from the information we discovered on the process itself, we also learned that children are often not willing to put forth the effort to produce reliable, consistent results [Seed, et al. 2010].

1.2 Virtual Reality Use with Children

With the release of HTC's Vive and the Oculus Rift, along with the release of Sony's virtual reality headset on the way, virtual reality has never been in a better position among the gaming community than it is now. However, VR has found favor outside the gaming industry as well. For instance, many teachers have begun using virtual reality games to better motivate their students in subjects like math, history and science [VR Society]. VR has even been used in training children in Israel the importance of looking both ways before crossing the street, a demographic that accounts for 20% of all pedestrian deaths in the country [Nuwer, 2015].

1.3 Virtual Reality and Pediatric Healthcare

Virtual reality has recently been utilized as a form of therapy for

children with medical issues. One example, VR Kids, a non-profit organization that aims to bring a "therapeutic virtual world" to patients in both “the home [and] hospital." They "tailor [their] experiences for each person" and "extensively explore the positive mental and physical connections forged in virtual reality." They even bring relaxing, immersive experiences to children about to undergo operations, a time that is stressful and scary to many young patients [VR Kids].

Additionally, clinicians have utilized VR games and interactive computer games to act as a therapeutic/motivational method when trying to manage cerebral palsy in children. While the studies are “limited,” “the available data suggest exciting prospects for the use of virtual reality in the rehabilitation of children with physical disabilities” [Weiss, et al. 2014].

2 Design of PulmonaReality

We conceived our initial idea based on previous personal experience with our medical subject. Growing up with chronic lung disease, Jacobson, the first author had to undergo pulmonary function tests often to check the progression of his illness. Many children with asthma or other lung-related issues have to regularly perform these tests. The tests occasionally are equipped with a small animation to help incentivize children to perform them (ex. “balloons” or “candles”). However, while the animations have been recently updated, within the past couple of years, we have met with a local pediatric physician who claims that some children are still somewhat reluctant to perform reliable respiratory tests for the pulmonary technicians at her practice.

We aim to create a more immersive environment for children, similar to VR Kids, to help incentivize them to provide more reliable statistics and be more willing to participate the test. In addition, we designed our interactive system to add gamification of the procedure to act as a form of respiratory “training” or “therapy.”

Figure 2: *Child interacting with PulmonaReality*

Our objective was to create a virtual reality program using a 3D game engine, Unreal Development Kit [UNREAL Game Engine, 2015] that was integrated with Oculus Rift [Oculus Rift, 2015], and a custom built electronic spirometer. In the early prototype, we had users blow into a paper bag that emulated the electronic spirometer while wearing an Oculus Rift which played videos timed with their exhalation. These initial trials provided ample results which helped drive the design, development, and implementation of our final VR simulations.

3 Project Implementation

3.1 Unreal Game Engine

We built our virtual environments using a combination of custom assets created in Autodesk Maya and prefabricated assets included in the program. The majority of the coding was done visually using the “Blueprints” feature that allows procedural programming. Unreal has beautiful shaders within the program, which enhanced the visual quality of our demos. It also works well with the Oculus Rift, which we had previously selected to use as our VR headset. This might change later due to costs and increase in basic consumer-grade VR tech gears. We mapped the user’s respiration data into the Unreal Engine via Arduino and serial communication.

3.2 Spirometer & Code

The spirometer was created using an Arduino board along with the following materials: PVC pipe, plastic tubing, glue, a Honeywell ASDX Ultra-low Silicon pressure sensor, a micro USB cable, and wires for circuitry purposes. The general design of the electronic spirometer was based on the design of a low cost custom-built electronic spirometer shared on Instructables [Instructables, 2015].

4. User Feedback

While more in-depth user studies are still needed to be completed, preliminary user studies have provided promising feedback. The users that were able to utilize all of PulmonaReality seemed very immersed in their chosen environments. They seemed to gravitate towards goal oriented experiences, rather than just being immersed, which led to further gamification of our level design. The users were enthralled in the experience and were able to use the spirometer, without feeling uncomfortable by the device.

References

Instructables: http://www.instructables.com/id/Low-CostSpirometer/

Nuwer, Rachel. "In Israel Kids Cross Streets in Virtual Reality for Safety Science." Editorial. Scientific American n.d.: n. pag. Scientific American. 1 Dec. 2015. Web.

VR Kids. http://www.vrkids.org/index.html

Oculus Rift. https://www.oculus.com/

Seed, M.Sc., RCPT(p), Laura, Allan Coates, M.D., Susan Carpenter, RN, and Jennifer Leaist, RN, BScN. "Pulmonary Function Testing." Aboutkidshealth. Sick Kids, 17 Mar. 2010. Web.

UNREAL Game Engine: https://www.unrealengine.com

Virtual Reality Society: http://www.vrs.org.uk/virtual-reality-education/educational-games.html

Weiss, Patrice L Tamar, Emanuel Tirosh, and Darcy Fehlings. "Role Of Virtual Reality For Cerebral Palsy Management." Journal Of Child Neurology 29.8 (2014): 1119-1124. MEDLINE Complete. Web. 25 Apr. 2016.