EE267 Project Proposal:
Unity Shooting Range with Haptic Feedback

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1 Motivation and Problem Statement

We plan to build a virtual environment using Unity, and give an in-person demonstration. The various components of the virtual scene we intend to build are detailed below. At a high level, we plan to create a simple interactive game using a custom-built haptic feedback controller. For stretch goals, we'd like to incorporate some dynamic elements and audio.

Scene Layout

- The Scene Setup
  - Main scene is an outdoor shooting range (likely procured through the Unity marketplace).
  - Targets will be displayed at the shooting range.
    - Going in plan is 3, static targets.
    - Stretch goal is to have more targets and to animate them.
- The "Game" Elements
  - User will be able to "move" (aka adjust their view) Up/Down/Left/Right using the buttons on the 4 buttons on the Arduino Uno controller.
  - User will push the CTL button on the Arduino Uno controller to fire a "gun."
  - A projectile (likely a small round ball) will fire and move toward the target with a high velocity.
    - If the target is hit, the user will feel a gentle 1 second vibration in the controller, the target will animate and rotate down with a mark on the target where the ball hit, the ball will bounce off the target and remain on the ground, and a score displayed to the user will increment. Stretch goal would be to integrate audio.
    - If no target is hit, the user will feel no vibration and the ball will bounce around the scene.
  - The game ends when all of the targets are hit.

2 Previous and Related Work

In recent years, research in the areas of virtual and augmented reality has exploded. As we've learned in class and seen at talks (such as that given by Professor Mann), the miniaturization of traditionally large and unwieldy components for our smartphones and other gadgets has led to a neverending torrent of creativity and experimentation in VR.

Currently, VR scenes are being built for any number of reasons and in numerous ways. Scenes are being created to look at psychological effects, to simulate real-world workflows [5], and even to see if a user might prefer a specific seat in a theater [2]. When designing a VR scene, it is best to go in with a plan and a structured approach to achieve a specific goal. One must consider the purpose of the scene as well as the I/O devices involved in accessing it [4]. There are any number of consumer-level I/O devices currently being used for this purpose with many more in development. As we learned in a recent homework, it is also important to incorporate audio in order to get true presence, and people are currently thinking of new ways to capture that sound in a 3D manner [3].

Of course, there are limitations to the current tech. We still run into data throughput and data rate issues (per our lectures) and it is still difficult to recreate, to a photorealistic level of detail, real-world experiences. Work is being done in this area [1], but more will need to be done before we're capable of creating truly accurate real-world scenes.

3 What's New, Different, and/or Creative

For our project, we've decided to go with the "default" option, which is to create a scene. However, we wanted to go beyond simply moving around a static scene and add some elements of interaction. The idea is to add some game elements and some physics while giving the user some feedback in the form of vibration when they hit a target. We're doing some things that are new to us while expanding upon the material that we learned in class and learning how to use and interact with Unity.

4 Overview of Hardware/Software

Output Hardware

- ViewMaster Head Mounted Display
- Provided LCD and LCD Driver Circuit
- Haptic Feedback - Arduino Uno #2 with Piezo buzzer (1)

Input Hardware

- VRDuino tethered to front of HMD - Arduino Teensy + 6DOF IMU
- Arduino Uno #2 with 4-directional movement + Control (5) buttons

Rendering Hardware

- Tanuj's custom GPU server (Intel Core i7, Nvidia 1080 GPU card) connected to ViewMaster subassembly via HDMI

Rendering Pipeline

- Unity's integrated rendering pipeline to render content directly from the desktop computer to the head mounted display, which will be set up as an external monitor

5 Development Milestones

1. [**26 May (Fri)**]:
   (a) Display static scene with single viewport
   (b) Display dynamic scene with single viewport
2. [**28 May (Sun)**]:
   (a) Implement game with keyboard/mouse (movement, firing, target impact, score update)
3. [**30 May (Tue)**]:
   (a) Integrate VRduino+IMU into environment
   (b) Integrate Arduino Uno #2 (button input + piezo output) into environment
4. [**31 May (Wed)**]: Display completed scene with dual viewports (HMD-compatible)
5. [**2 Jun (Fri)**]: Have fully operational program, ready for demo
6. [**9 Jun (Fri)**]: Turn in code NLT and present demo

References

[1] CHEN, C. F., BOLAS, M., AND ROSENBERG, E. S., "Rapid creation of photorealistic virtual reality content with consumer depth cameras," *2017 IEEE Virtual Reality (VR)*, Los Angeles, CA, 2017, pp. 473-474.

[2] DORADO, J. L., FIGUEROA, P., CHARDONNET, J. R., MERIENNE, F., AND HERNANDEZ, J. T., "Comparing VR environments for seat selection in an opera theater," *2017 IEEE Symposium on 3D User Interfaces (3DUI)*, Los Angeles, CA, 2017, pp. 221-222.

[3] REINHARD, E., WARD, G., PATTANAIK, S., AND DEBEVEC, P., "On the development of a dynamic virtual reality system using audio and visual scenes," *2016 Twenty Second National Conference on Communication (NCC)*, Guwahiti, 2006, pp. 1-6.

[4] SEO, J., AND KIM, G. J., "Design for Presence: A Structured Approach to Virtual Reality System Design," in *Presence*, vol. 11, no. 4, pp. 378-403, Aug. 2002.

[5] VIERJAHN, T. ET AL., "Towards a design space characterizing workflows that take advantage of immersive visualization," *2017 IEEE Virtual Reality (VR)*, Los Angeles, CA, 2017, pp. 329-330.