

CS 6334.001 Virtual Reality Project Description

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1. Project Goal

The goal of this course project is to build a prototype system for virtual reality or augmented reality. The system needs to have at least the following four components:

- A virtual world generator. The Virtual World Generator (VWG) generates the content of the system. Depending on what applications of the VR/AR system, students can design the VWG accordingly.
- A visual renderer. We will use images as the main stimuli. Therefore, a visual renderer is required to render the virtual world into images.
- A visual display. The rendered images should be displayed to some devices for the users.
- A user interaction mechanism. A user should be able to interact with the virtual world. Different ways of interactions can be employed.

Figure 1 illustrates an overview of a VR system.

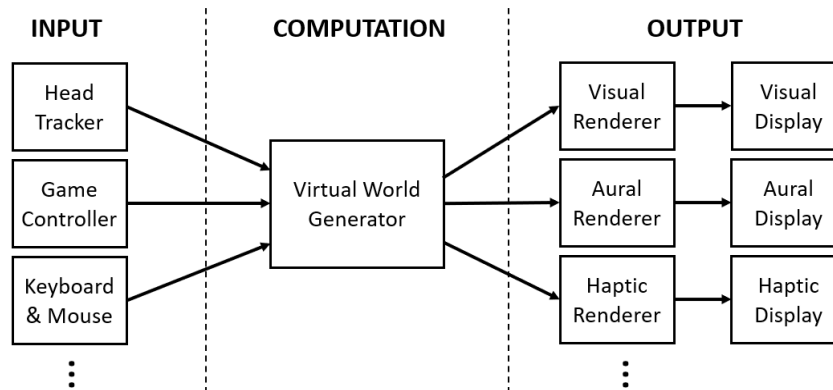


Figure 1. An overview of a virtual reality system

2. Virtual Reality vs. Augmented Reality

The first question to ask when proposing a project is

- Will your project focus on virtual reality or augmented reality?

The main difference between VR and AR is that AR uses the real world in the virtual world generator. Therefore, AR requires more interactions with the real world such as using a camera to capture the real world and tracking objects or markers in the real world. On the other hand, AR requires less efforts in designing the virtual world.

3. Choosing the Application Environment

We can utilize either game engines or physics simulators as the application environment. Students can decide based on the application and experiences with these tools. Here are a few commonly used environments:

- Unity Engine <https://unity.com/> (Supported by Google VR SDK)
- Unreal Engine <https://www.unrealengine.com/en-US/> (Supported by Google VR SDK)
- PyBullet Simulator <https://pybullet.org/wordpress/>
- Blender <https://www.blender.org/>

4. Designing a Virtual World

For VR, we can utilize existing 3D models or design new 3D models of the virtual world. For AR, we can capture the real world and use it in the virtual world generator.

To facilitate building the virtual world, here are a few repositories of 3D models/assets of objects:

- 13 Sites with Free 3D CAD Models <https://www.scan2cad.com/cad/free-3d-cad-models/>
- The ShapeNet repository of 3D object models <https://shapenet.org/>
- The Google scanned objects <https://app.ignitionrobotics.org/GoogleResearch/fuel/collections/Google%20Scanned%20Objects>
- The YCB Object and Model Set <https://www.ycbbenchmarks.com/object-models/>

Here are some repositories of 3D models of environments:

- The Gibson Environment (indoor) <http://gibsonenv.stanford.edu/>
- The SAPIEN environment (indoor) <https://sapien.ucsd.edu/>
- The HABITAT environment (indoor) <https://aihabitat.org/>
- The CARLA simulator (outdoor) <https://carla.org/>

The Google VR SDK can be used with different platforms: <https://developers.google.com/vr>.



Figure 2. An example of a cardboard VR glasses



Figure 3. An example of a VR controller

5. Designing a Visual Renderer

Depending on the selected programming environments such as Unity or PyBullet, students can use the provided APIs to render images of the virtual world. A design choice to be determined is whether to render a monocular image or a stereo image for both eyes.

6. Choosing a Visual Display

Rendered images could be simply displayed onto a window in the programming environment such Unity or PyBullet.

We offer another option using Cardboard VR glasses, which is a simple head mounted display with a cellphone. Figure 2 shows an example of such a VR glasses. The Google Cardboard VR SDK can be used for development: <https://developers.google.com/cardboard/develop>.

7. Designing an Interaction Mechanism

Users of the VR/AR system should be able to interact with the virtual world. Depending on the applications, different ways of interactions can be employed such as navigating in a virtual environment, selecting and manipulating an object, or controlling a robot, and so on.

For the input device for interaction, students can simply use keyboards and mice. We offer another option to use a VR controller as shown in Figure 3. The controller can be connected to a phone or a pad and provide user inputs to the application.

8. Going Beyond

The VR/AR system for this course project is not limited to the aforementioned components. Students are encouraged to introduce new components to improve the system such as using audio, incorporating head tracking and eye tracking or using other input device or display device.