Introduction to VR/AR

*Midterm Examination, Spring 2020*

The midterm has three questions of equal weight. Some questions have sub-questions, each of equal weight. Some sub-questions are required only for CS 590 students, and are not required for CS 490 students. CS 490 students should not answer the CS 590 only sub-questions.

FIRST NAME:

LAST NAME:

PUID:

**Question 1**. Virtual Reality (VR) can be used to treat the fear of heights.

1. Describe a VR app for treating the fear of heights that proceeds progressively, by increasing the strength of the fear of heights stimulus.
2. What are the advantages of using VR to treat the fear of heights, compared to a method that relies on a real world glass elevator, which the patient rides repeatedly, to higher and higher heights?

**Question 2.** One of the VR approaches for alleviating the difference in size between a larger virtual environment (VE) and the smaller physical space hosting the VR application is redirected walking.

1. Why is the size discrepancy between the real world and the VE an issue?
2. How does redirected walking work?
3. When does redirected walking work best?
4. What are the limitations of redirected walking?

**Question 3**. A group of tourists are at the top of the Grand Canyon, looking into the abyss. A canyon is a huge hole in the ground, e.g. 10 miles wide and 1 mile deep, with abrupt edges. Of course, everyone has their camera out and takes many pictures of the canyon, in many directions. The pictures are conventional snapshots and not panoramas. The canyon is deep and far enough for the images to be considered as taken from the same viewpoint. Do not worry about tourists appearing in the pictures. Pictures are taken in many directions. There is overlap between pictures. There might be some directions that are not covered by any picture. An eagle (i.e., a bird) flies across the canyon and appears in some of the pictures. You have access to all the pictures and your goal is to put together a VR app that lets a user see the Grand Canyon with a VR headset.

1. Describe a method for stitching the images together into a cube map, ignoring the moving parts of the scene, i.e. the flying eagle. You are given the field of view of each camera, as well as the resolution of each image. You need to find the pose of each camera. Let’s say camera C0 defines the world coordinate system, so you have to find the three rotations (pani, tilti, rolli) that place camera Ci in the world coordinate system.
2. **CS 590 ONLY**. Describe a method for stitching the images together into a video cube map, i.e. a video where each frame is a cube map. Each image has a time stamp that specifies the time it was taken up to the minute, and NOT up to the millisecond.
3. **CS 590 ONLY**. Given a planar pinhole camera PPC0 described by vectors (a0, b0, c0), a second planar pinhole camera PPC1 described by vectors (a1, b1, c1), both with eye at (0, 0, 0), and a point (u0, v0) on the image plane of PPC0, provide the equations necessary and sufficient to derive the coordinates of the corresponding point (u1, v1) on the image plane of PPC1.