360° Vision With HMD and FOV Compression

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1. Elevator Pitch

I will allow users to experience 360° vision with a VR headset. Users will wear a commercial HMD with a wide FOV (~110°) that has been equipped with a 360° camera. Both HMD and camera will be tethered to a PC, which processes the camera output and sends it to the HMD. Stretch goals include using convergence to allow depth perception and experimenting to see how well a user can adjust to this view with enough practice.

2. Extended Overview

Having "eyes in the back of your head" is not just a cool idea for a 3rd-tier superpower, it could also be useful for specialized real-world applications in the military and elsewhere.

Our natural human vision has a much larger field of view than even the best VR headsets. Under normal circumstances, then, the HMD reduces the visual field, rather than increasing it. Using FOV compression to simulate a substantially larger field of view could, with enough training, give users the superhuman ability to see in every direction.

Unity's built-in VR support will enable rapid development and ideally make distortion correction easier, since the video can be projected onto concave geometry. It should also allow for easy experimentation with convergence to see whether it can be used to minimize dizziness and acclimation time as well as to increase depth perception.

The radical change in visual information being passed to the brain will no doubt require significant acclimation. The dizziness and nausea that users of VR headsets sometimes feel, especially on first-time use, will no doubt be more pronounced because of the FOV compression. Therefore, the most interesting aspect of this project is whether this additional hurdle can be overcome through regular use of the HMD.

Compared with normal human vision, using an HMD causes significant visual information to be lost. The amount of information lost is dependent on the camera resolution. However, even with a camera of infinite resolution, the HMD display resolution would cause nearly as much information loss. Even with a 110° FOV, users can distinguish individual pixels; reducing the pixels per degree by a factor of more than three would result in a significant loss of detail. Therefore, with this hardware, users will not perform any tasks that require recognition of fine details.

Furthermore, the lack of depth information when each eye sees the same view could prove to be a hindrance. While I hope to mitigate this with convergence settings, it is unlikely that there exists a setting that allows the human brain to extract depth information from the compressed FOV. In that case, I will simply do without depth information and structure the tests accordingly.

2.1 Technical Challenges

The primary technical challenges for this project are:

- General VR development in Unity

- Low-latency processing of camera video
- Video distortion correction
- Adjusting video (positioning, movement, etc.) to be user-friendly

2.2 Risks and Mitigations

The primary risks for this project are:

- Incompatibilities with Unity and camera hardware / API. I'll check the Unity forums to see what models people have used successfully
- Dizziness / nausea for demo users. I'll be on hand to perform the demo myself, which should be sufficient if I've acclimated by then
- High latency: any tests based on quick reactions will not work if the latency between camera and HMD is too high. The mitigation for this risk will simply be to have different tests
- Unknown VR-related risks: development in VR has many potential pitfalls that are not obvious until you run into them. The mitigation for this risk is browsing Unity forums, Youtube tutorials, etc. before starting development

3. Hardware and Software

[Requested] Valve Index Headset + Lighthouse (for demo day only, not for dev)

[Requested] Desktop PC with GeForce 1070+ or equivalent video card (for demo day only, not for dev). Note: Student can provide video card if PC with sufficient PSU and PCI-E slot is supplied

[Requested] 360° Video Camera: no model preference as of now, although one that can be affixed upright to the Valve Index Visor without too much trouble would be ideal

[Personal] Valve Index + accessories (for dev): provided by student

[Personal] Unity: provided by student

[Personal] Desktop PC (for dev): provided by student

4. Team Responsibilities

As of now, this is a 1-person project.

5. Development Plan

The milestones for this project are as follows:

- March 2: Technical design completed
- March 6: 360 video working in Unity
- March 9: 360 video working on Index
- March 11: Distortion correction completed
- March 13: Camera affixed to headset and virtual position of camera fixed
- March 14: (Optional) Convergence experiments
- March 16: Demo tasks finalized
- March 18: Final report completed

- March 19: Finalize demo
- March 20: Demo Day!