CSE 190: Virtual Reality Technologies

LECTURE #13: REPROJECTION

Upcoming Deadlines

Sunday, May 16: Project 3 due

Monday, May 17: Discussion Project 4

Sunday, May 23: Project 3 late deadline

Monday, May 24: Discussion Project 4

Sunday, May 30: Project 4 due

App Presentations

Aarushi Shah

Late breaking headset news

HTC presented 2 new headsets at ViveCon virtual event today:

Vive Pro 2:

- 2448×2448 pixels per eye
- 120 degree FOV
- 120Hz refresh
- Tethered, available wireless adapter
- \$799 (headset only), \$1399 (w/Lighthouses and controllers)

Vive Focus 3:

- Qualcomm XR2 (same as in Oculus Quest 2)
- 2448×2448 pixels per eye
- 120 degree FOV
- 90Hz refresh
- Swappable battery pack
- \$1300, targeted for businesses







Mitigating Rendering Latency

Rendering an image in stereo takes about 10 milliseconds.

Problem:

• By the time rendering is done, the user may have moved their head.

Pose Prediction

Predict what head pose is when images are displayed by extrapolating current head motion.

Two options:

Constant rate: Assume the currently measured angular velocity will remain constant over the latency interval.

Constant acceleration: Estimate angular acceleration and adjust angular velocity accordingly over the latency interval.



The idea of Timewarp has been around in VR research for decades, but the specific feature was added to the Oculus software in April 2014 by John Carmack.

Standard Timewarp in itself does not help with framerate. It was made to lower the perceived latency of VR.

Timewarp reprojects an already rendered frame just before sending it to the headset to account for the change in head rotation.

That is, it warps the image geometrically in the direction you rotated your head between the time the frame started and finished rendering. Since this takes a fraction of the time that re-rendering would and the frame is sent to the headset immediately after, the perceived latency is lower since the result is closer to what you should be seeing.

Time Warp Explained



https://www.youtube.com/watch?v=WvtEXMIQQtI&t=2s

Asynchronous Time Warp (ATW)

Asynchronous Timewarp takes the same concept of geometric warping and uses it to compensate for dropped frames.

If the current frame doesn't finish rendering in time, ATW reprojects the previous frame with the latest tracking data instead.

It is called "asynchronous" because it occurs in parallel to rendering rather than after it. The synthetic frame is ready before it's known whether or not the real frame will finish rendering on time.



Asynchronous Space Warp (ASW)



When an application fails to render frames at 90Hz, the Rift driver drops the application down to 45Hz with ASW providing each intermediate frame.

ASW works in tandem with ATW to cover all visual motion within the virtual reality experience.

ASW applies <u>animation detection</u>, <u>camera translation</u>, and <u>head</u> <u>translation</u> to previous frames in order to predict and extrapolate the next frame.

ASW Explained



https://www.youtube.com/watch?v=eAl2l 1KfqQ&t=1239s

IDEAL VR PIPELINE



DROPPED FRAME



SYNTHESIZED FRAME



ASW – Results

As a result, motion is smoothed and applications can run on lower performance hardware:

- Nvidia 960 or greater (down from GTX 970 or greater)
- Intel i3-6100 / AMD FX4350 or greater (down from Intel i5-4590 equivalent or greater)

ASW tends to predict linear motion better than non-linear motion.

ASW – Visual Artifacts

ASW has problems with:

- Quick brightness changes
- Rapidly-moving repeating patterns in the environment
- Head-locked elements that move too fast to track properly

Spacewarp is a band-aid rather than a real performance optimization

Alternatives to ASW:

- Reduce rendering resolution
- Reduce polygon complexity
- Reduce texture detail
- Reduce time spent on non-rendering tasks

ASW 2.0

Unlike the other techniques, ASW 2.0 won't work on just any app. The developer has to submit their depth buffer each frame, otherwise it will fall back to ASW 1.0.

Asynchronous Spacewarp 2.0 is an update to ASW which enhances the quality of the technique by incorporating understanding of depth. When announcing the technique, Oculus showed the following scenario as an example of the visual artifacts the 2.0 update will eliminate:

Both Unity and Unreal Engine submit depth by default when using their Oculus integrations.



https://www.youtube.com/watch?t ime_continue=4&v=I3LGq5TmMkw