CSE 190: Virtual Reality Technologies

LECTURE #11: HMD OPTIMIZATION

Announcements

Midterm exam this Thursday during lecture in B210

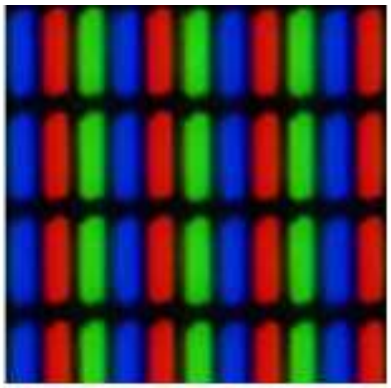
Final project description to be released this Friday

Screen Door Effect

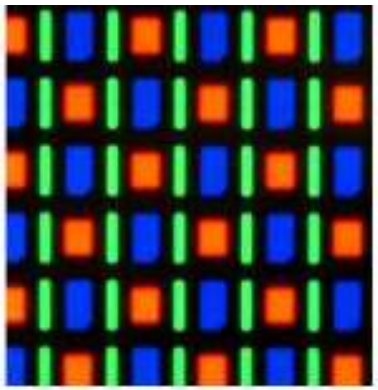
Because pixels on LCD and OLED displays have dead space in-between them image looks like looking through a screen door when looking at it through magnifying lenses.

The brighter the image and the more homogeneous the surfaces, the more visible the effect.

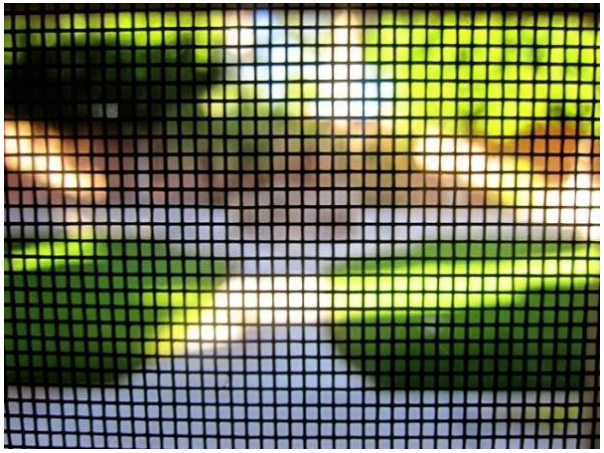
There is no software solution to mitigate the effect, except to use dark backgrounds.



LCD
DK1



OLED
DK2

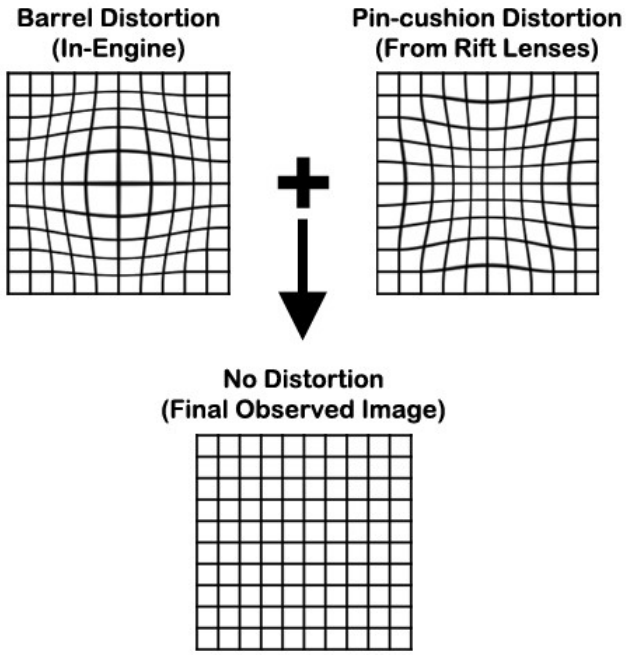


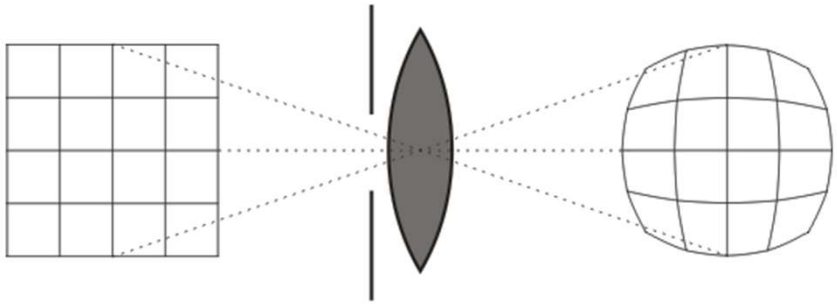
Screen Door

Lens Distortion

All VR HMDs have lenses which distort the image.

VR engine has to render a pre-distorted image so that the user will see a correct, undistorted image. A simple pixel shader can do this.





Chromatic Aberration

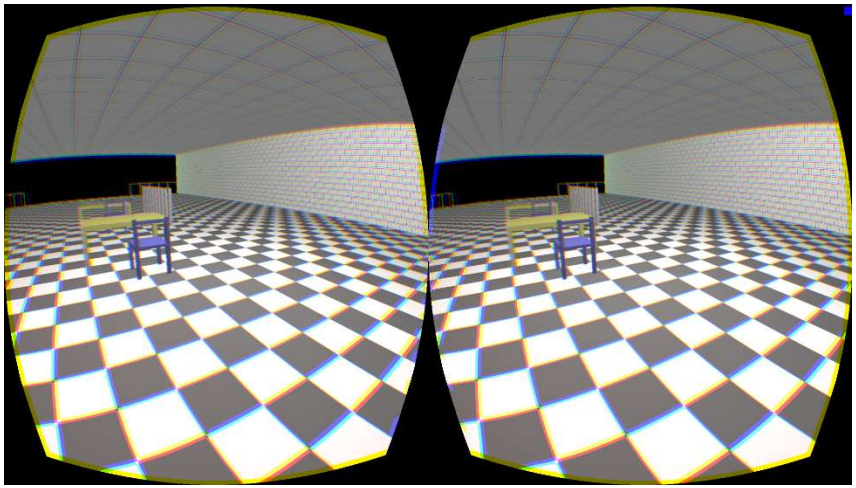
Arises from the inability of a lens to focus all colors in the same place.

FOcal length depends on refraction.

blue and red light have different indexes of refraction → their focal length is also slightly different.

Chromatic aberration is clearly visible on photographs or video as the color channels are not perfectly aligned.

Remedy: apply “Brown's model” distortion correction formula to each color channel independently.

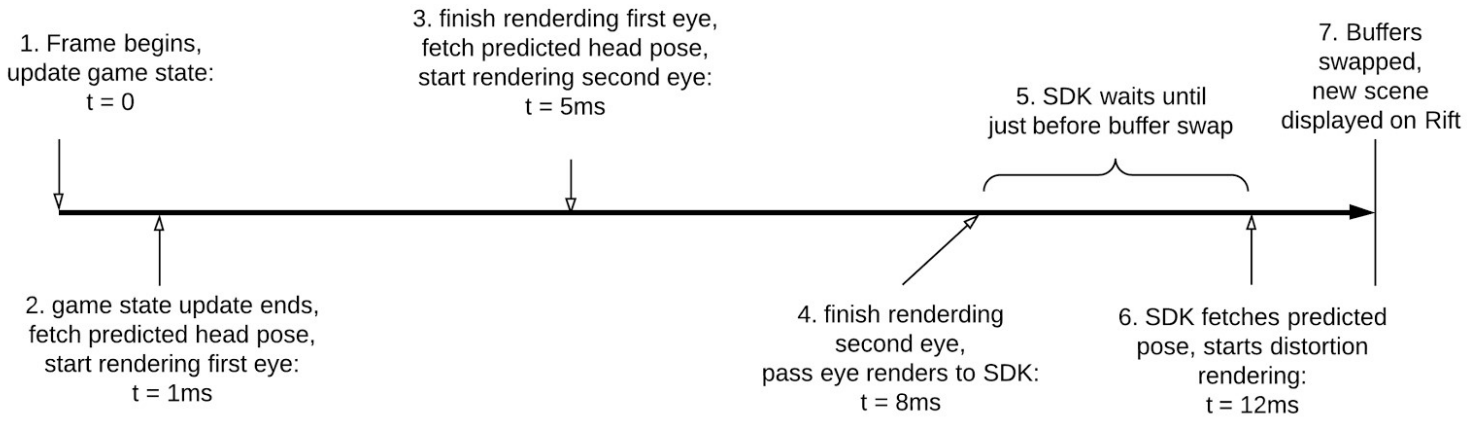


Optimizations: Asynchronous Time Warp

Image space scene shift just before frame display

Reduces latency

Only works for head orientation changes

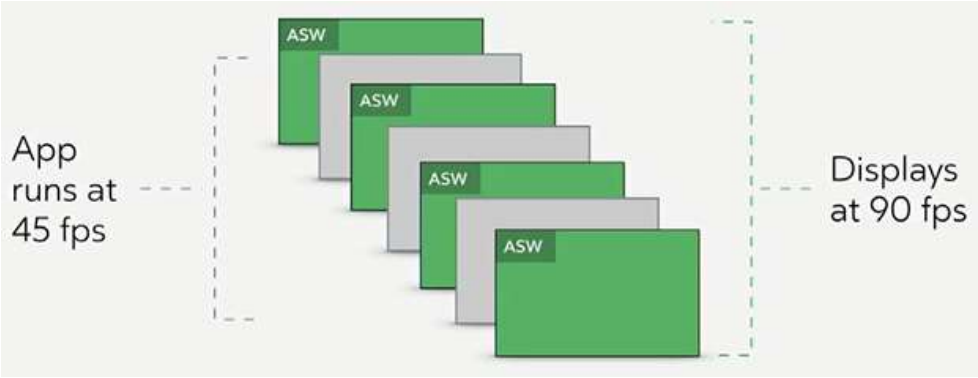


http://rifty-business.blogspot.com/2014/08/using-timewarp-on-oculus-rift.html

ATW

1. Predict head orientation for when buffer swap happens
2. Render first eye for predicted head orientation, render a larger image than needed
3. Predict head orientation for when buffer swap happens
4. Render second eye for predicted head orientation larger than needed
5. Fetch head orientation prediction again
6. Shift images to match latest prediction
7. Show both eye images by doing buffer swap

Optimizations: Asynchronous Space Warp



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 animation detection, camera translation, and head translation to previous frames in order to predict the next frame.

This includes character movement, camera movement, Touch controller movement, and the player's own positional movement.

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

Space warp 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

NVIDIA SMP (simultaneous multi-projection)

Up to 16 independent viewports can be projected simultaneously in one rendering pass

- Includes stereo (=2 viewports)

Video (1’50+): https://www.youtube.com/watch?v=p6NbyEmPalA