

Visual Rendering for VR

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Stereo Graphics

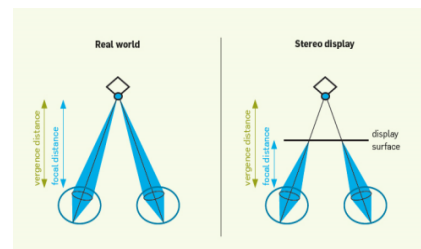
- Our left and right eyes see two views, which are processed by our visual cortex to create a sense of depth
 - Computer renders slightly-different views for the two eyes
 - Different approaches



Vergence-Accommodation Conflict

Scientific Literature has identified vergence-accommodation conflict causes a variety of psychophysical problems including:

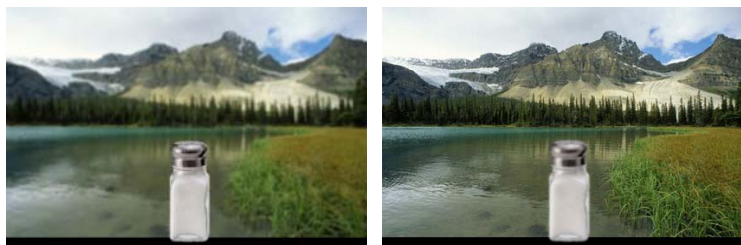
- induced binocular stress
- difficulty in fusing the two images into a stereo pair
- the perception of scene geometry
- discomfort



(Image is from [Kroeker 2010]).

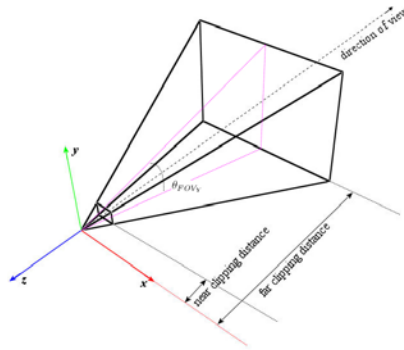
The Challenge

- Popular press has reported a number of viewers complaining about 3D movies giving them headaches, nausea, blurred vision, and other symptoms of visually-induced motion sickness
- A principal suspect is widely believed to be the vergence-accommodation conflict



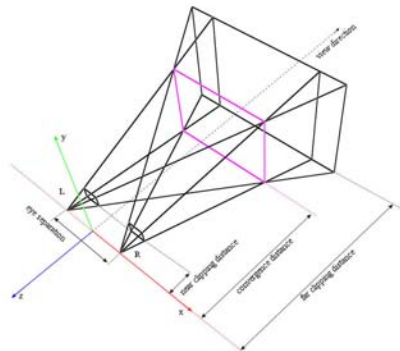
From: <http://gemmahodgson.wordpress.com/tag/salt-shaker/>

Frustum projection



<http://www.animesh.me/2011/05/rendering-3d-anaglyph-in-opengl.html>

Stereo frustum



<http://www.animesh.me/2011/05/rendering-3d-anaglyph-in-opengl.html>

Stereo frustum

Parallel

Toed-in

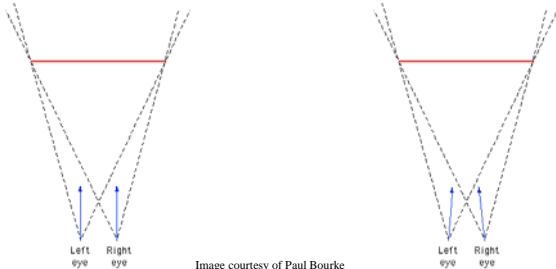
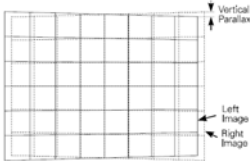
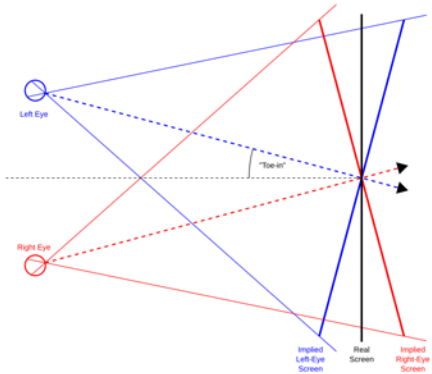


Image courtesy of Paul Bourke

Problems with toed-in approach



Keystone distortion



http://doc-ok.org/?attachment_id=78

Woods et al. (1993)

Creating stereo pairs with skewed-frustum

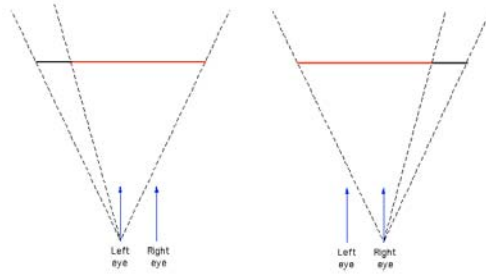


Image courtesy of Paul Bourke

Creating stereo pairs with skewed-frustum

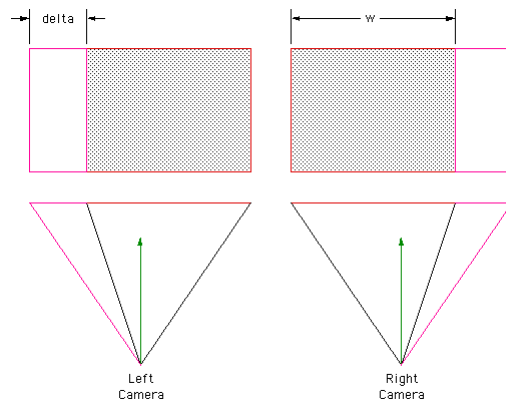


Image courtesy of Paul Bourke

Depth perception

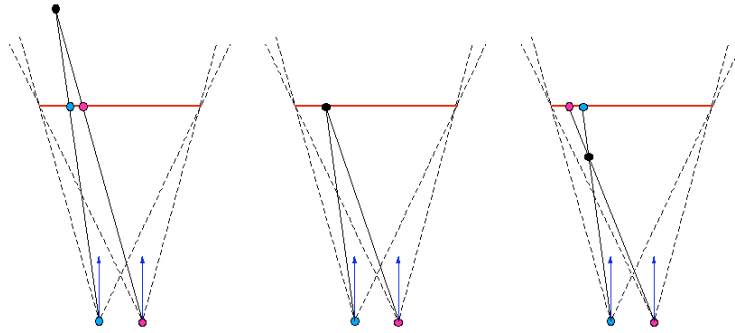


Image courtesy of Paul Bourke

Visual fatigue (Ukai and Howarth, 2008)

- Separation of color causes binocular rivalry
 - Constant switching between red and blue
 - Little is known about long-term health effects
- Inevitable cross-talk in polarized filters
- Time-sharing shutters reduce frame rate
 - Flickering is the most significant cause of visual fatigue
- Vergence-accommodation problem

Stereo Rendering

- Extra work for the second rendering
 - How can we minimize it
- Problems with stereo textures
 - Stereo makes textures/microgeometry look flat/painted-on

Easing Re-Rendering

- Image Morphing: 1997 Darsa, Silva, Varshney
- Post-rendering 3D Warping: 1997 Mark, Bishop, McMillan
- Time Warping: 2013 John Carmack

Goal: Reduce Latency

- Sensor Read
- Rendering
- Display

Goal: Reduce Latency

- Sensor Read 1
- Rendering
- Sensor Read 2
- Warping
- Display

On the Magic Leap discussion...

- A very fast configurable zone plate to provide nearly correct depth cues
 - Re-focus light at 12 levels of focus (0.25 to 3m)

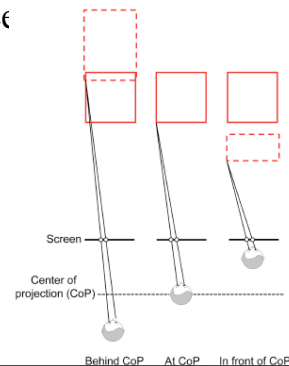


Multi-viewer

(Pollock et al. 2012)

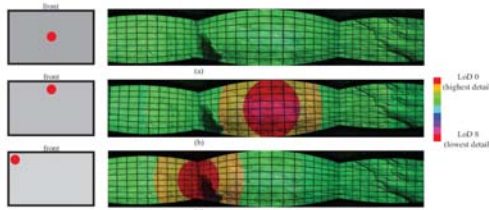
Viewers perceive depth differently, depending on where they are standing

- Less distortion with backward displacement
- Render correct stereo image based on the location of the viewer that is nearest to the screen



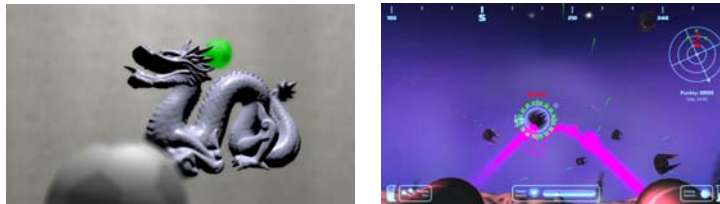
Acuity-driven rendering (Papadopoulos and Kaufman 2013)

- Stony Brook Gigapixel Display
- Humans can only discriminate two points that are $1/60$ angle apart
 - Therefore display lower resolution images when the viewer is far away from the display
 - Kind of like mipmapping



Gaze-driven rendering (Mantiuk et al. 2013)

- Depth-of-field visualization controlled by gaze direction
- Display information by looking at objects



LOD for 3D Graphics

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Lawrence Livermore National Lab

David Luebke

NVIDIA Research

Martin Reddy

Pixar

Amitabh Varshney

University of Maryland

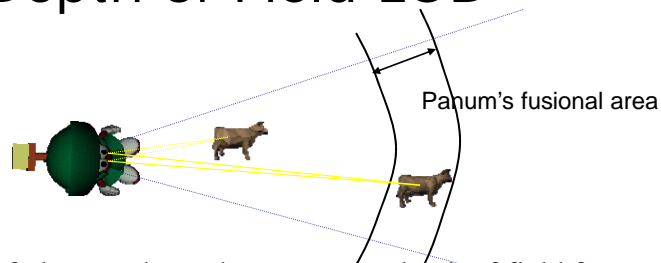
Ben Watson

North Carolina State University

Rob Huebner

Nihilistic Software

Depth of Field LOD

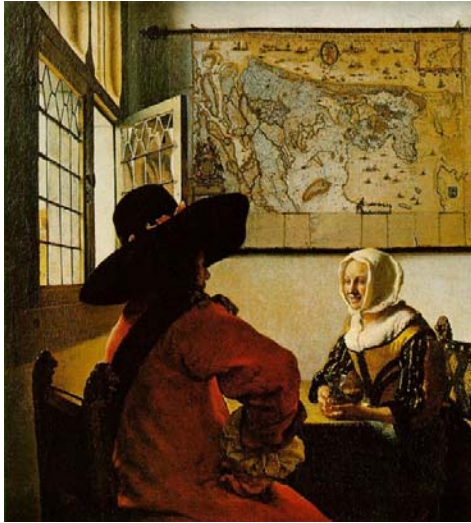


- Resolution of element dependent upon the depth of field focus of the user's eyes, i.e. objects out with the fusional area appear in lower detail
- Under binocular vision, both eyes converge on object at certain distance in order to focus retinal image
- Objects in front or behind this fusional area are unfocused, suffering from double images
- Must track both eyes accurately to evaluate convergence distance

Slide 24

Lecture 7

Visual Perception Software



Vermeer

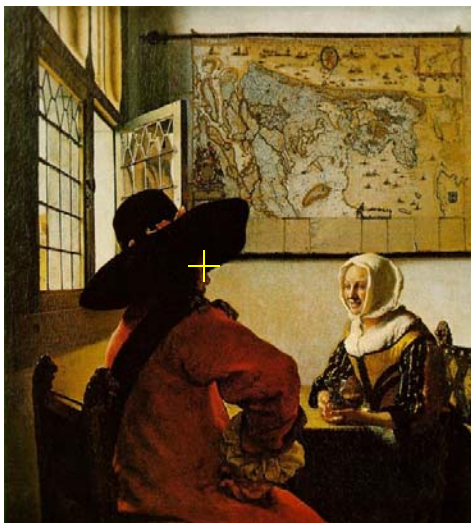
"Officer and Laughing Girl", 1658-60

120 x 135 degrees FOV

No eccentricity blurring

No velocity blurring

Visual Perception Software



Vermeer

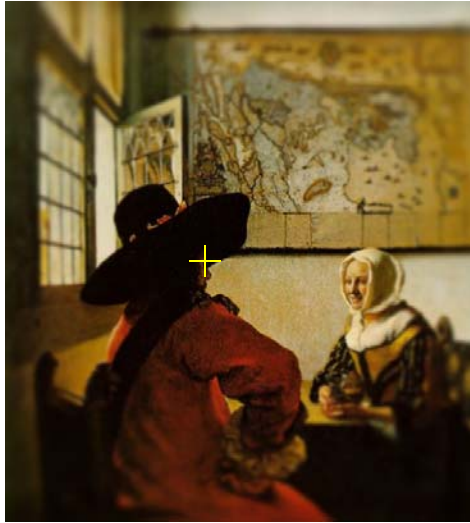
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Visual Perception Software



Vermeer

“Officer and Laughing
Girl”, 1658-60

120 x 135 degrees FOV

Eccentricity blurring

Velocity = 60 deg/s