CS 563 Advanced Topics in Computer Graphics Stereoscopy

by Sam Song

Stereoscopy

- Introduction
- Parallax
- Camera
- Displaying and Viewing
- Results

Introduction

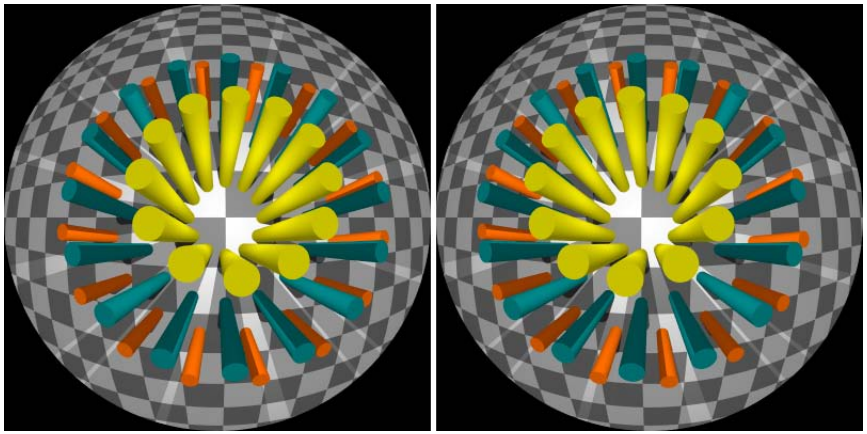
- Stereoscopy
  - What is it?
    - seeing in three dimensions
    - creates the illusion of depth in images
  - What causes it?
    - Binocular disparity
      - Difference between images in left and right retinas causes stereo effect
  - What is it used for?
    - Recreational
      - 3D Movies & Games
    - Research in visualization
      - medical imaging
      - aviation simulation
      - geographical data

Introduction

- How do we see depth?
  - Combination of Visual Clues
  - We can tolerate some inconsistency in clues
- Visual Clues
  - Binocular disparity (dominant depth cue)
  - Lighting & Shadows
  - Object occlusion
  - Perspective viewing
  - Detail
  - Size of known objects
  - Motion of objects with head movement
  - Accommodation
    - Focal length to focus at a particular depth
  - Convergence
    - Eye rotation so it is facing the focal point

Introduction

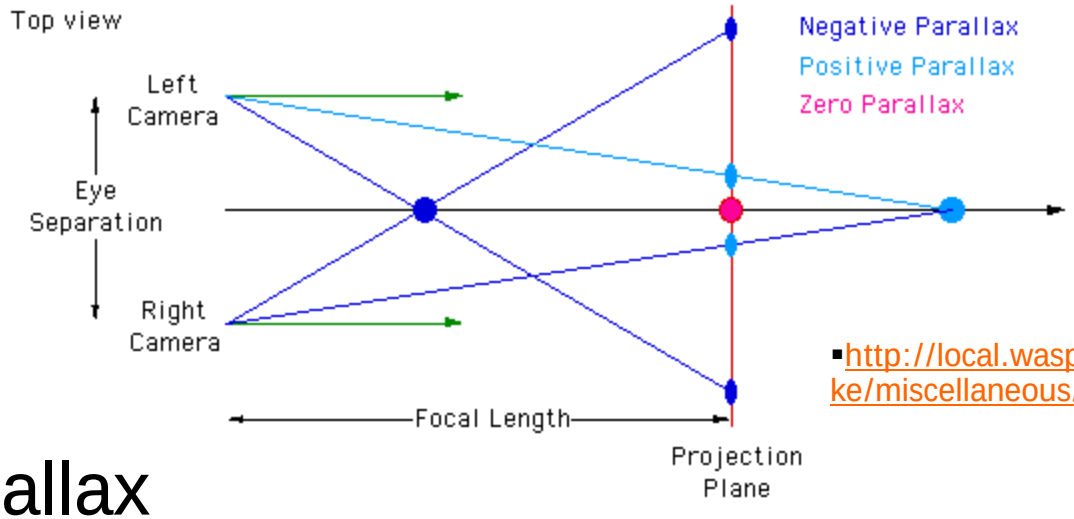
- Stereo pairs



  - Viewed such that our visual cortex will fuse them
  - Convergence
  - Binocular disparity
  - No accommodation

Parallax

- Create Left and Right Cameras
  - Camera separation: distance between cameras

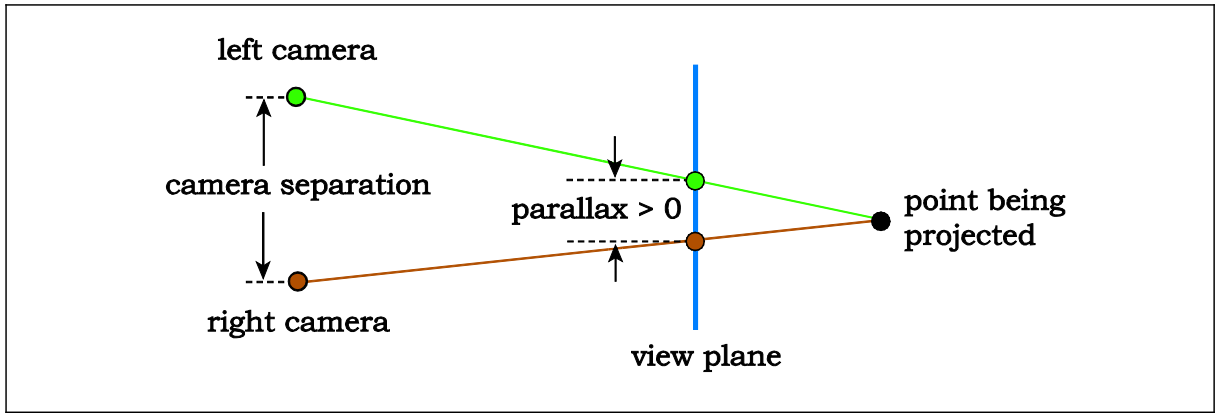


- http://local.wasp.uwa.edu.au/~pbourke/miscellaneous/stereographics/

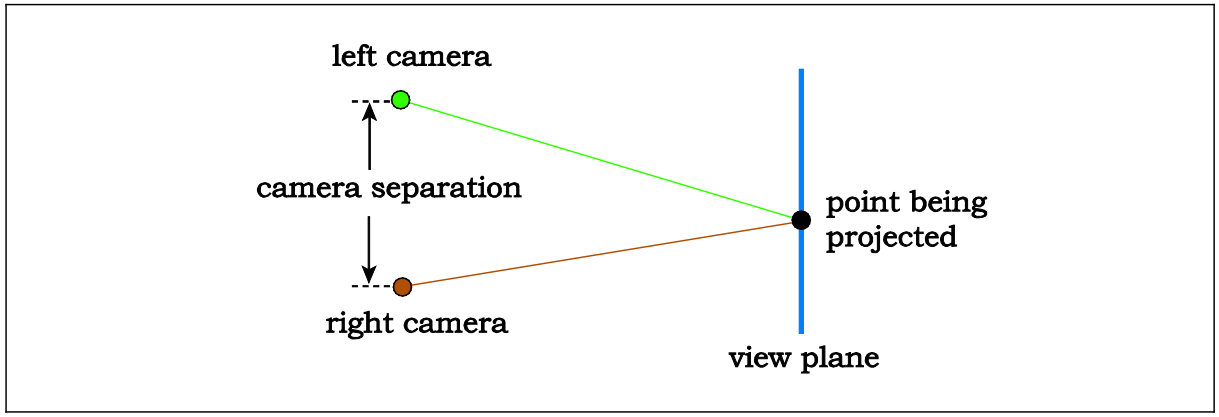
- Parallax
  - Displacement of a point being projected onto the view plane by the two cameras
  - Determines apparent distance
    - Size
    - Sign

Parallax

- Positive Parallax - Point behind the screen

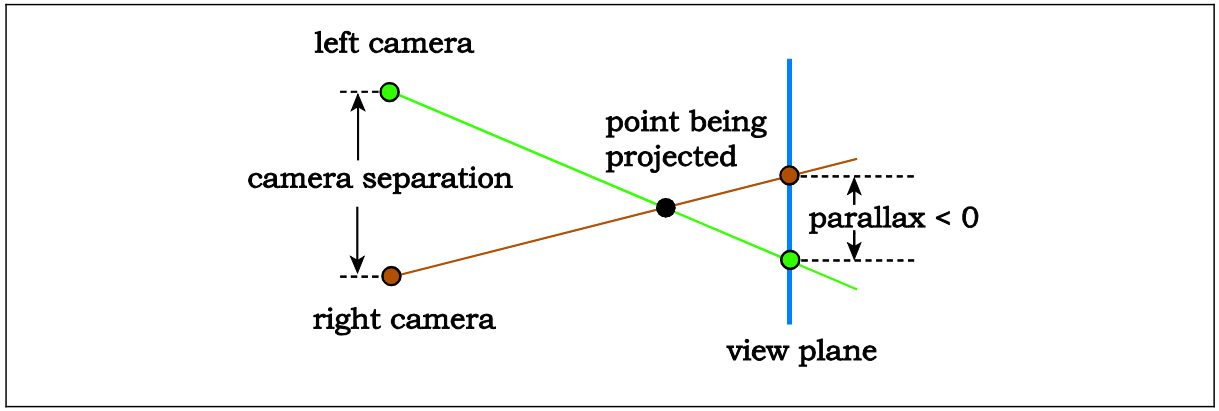


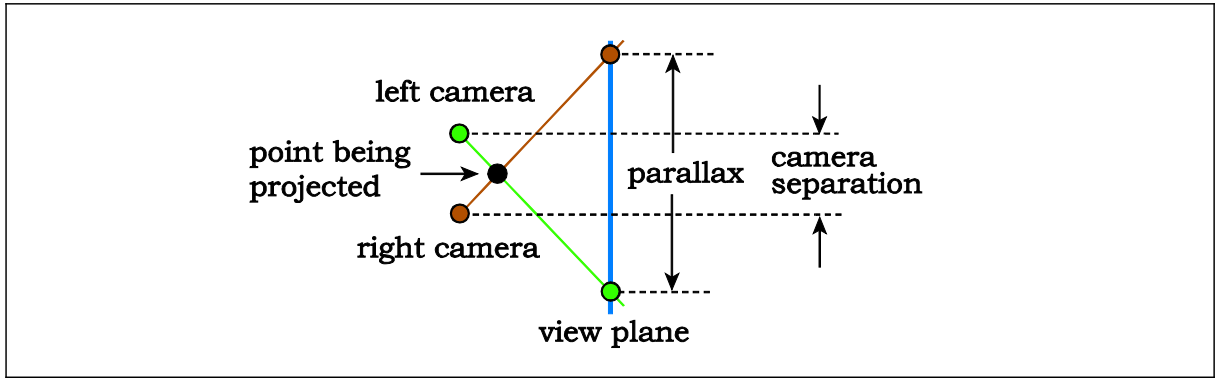
- Zero Parallax – Point on the screen



Parallax

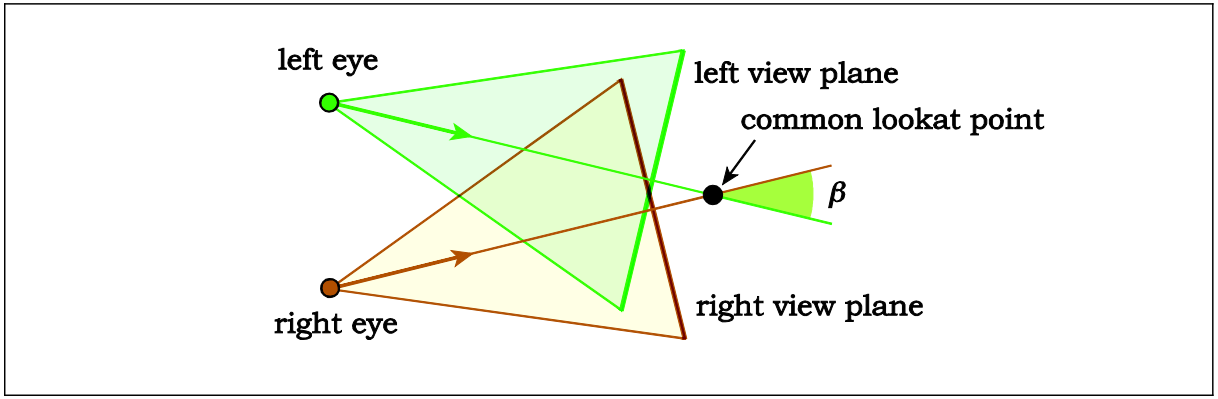
- Negative Parallax – Point in front of the screen





Camera

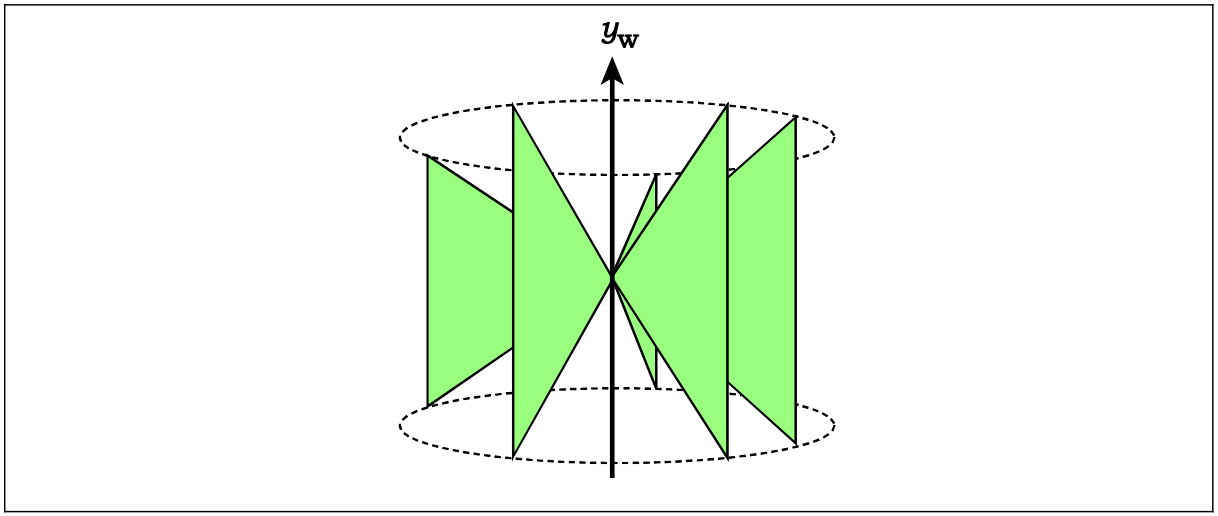
- How do we arrange the left and right cameras?
- Convergence may suggest both cameras use the same look at point
- Toe-in Camera Arrangement



- same look at point
- different view planes
- symmetric view frustums

Camera

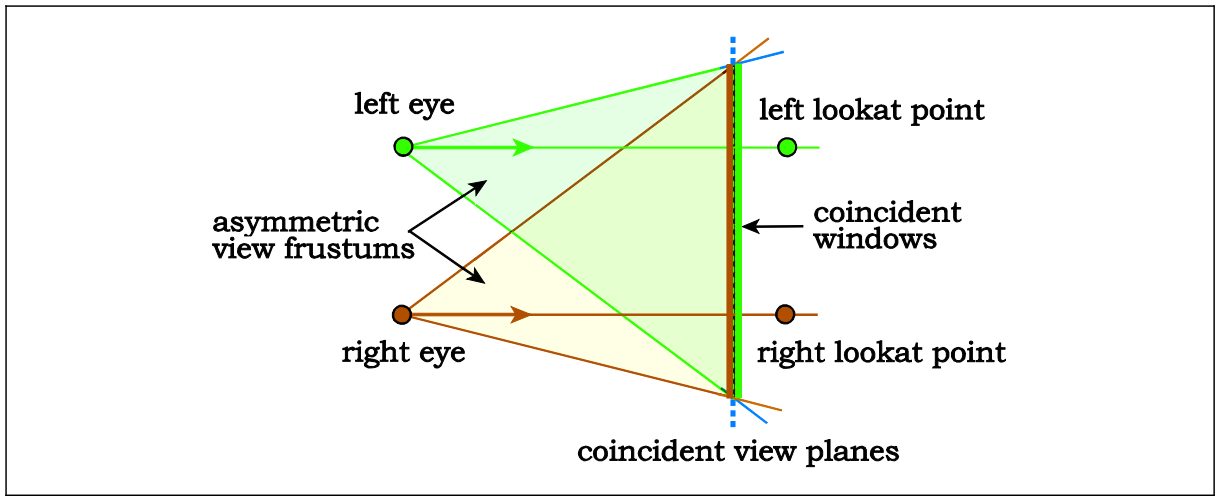
- How will the views of the left and right camera differ?
  - An Object centered at the look at point will be rotated by some angle β
- Vertical Parallax



- Images with vertical parallax are more stressful to fuse

Camera

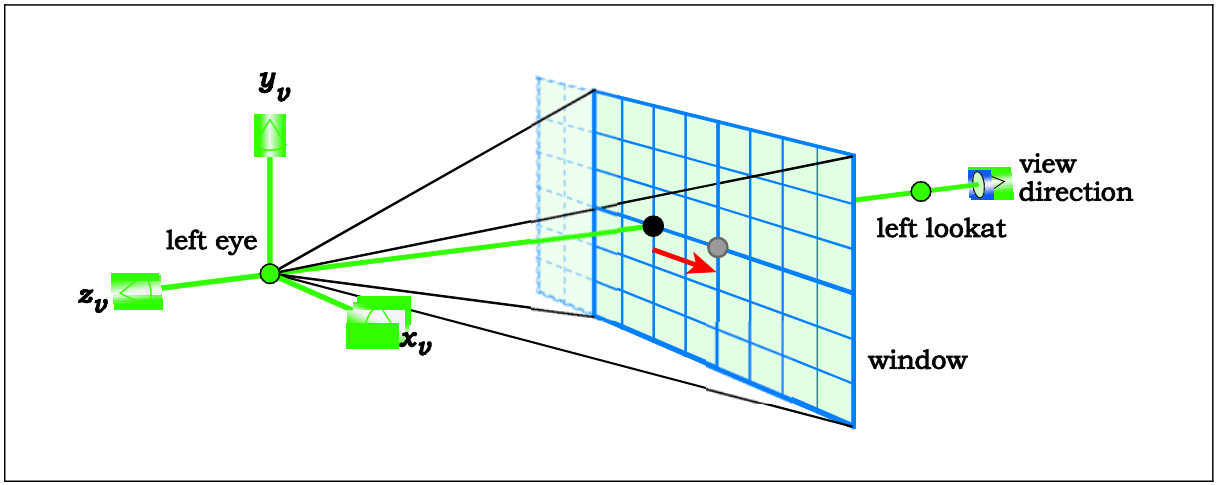
- Parallel Camera (Off-axis)



- Cameras has own look at point
- Cameras have asymmetric view frustums
- Parallel view planes
- Not supported in all rendering packages

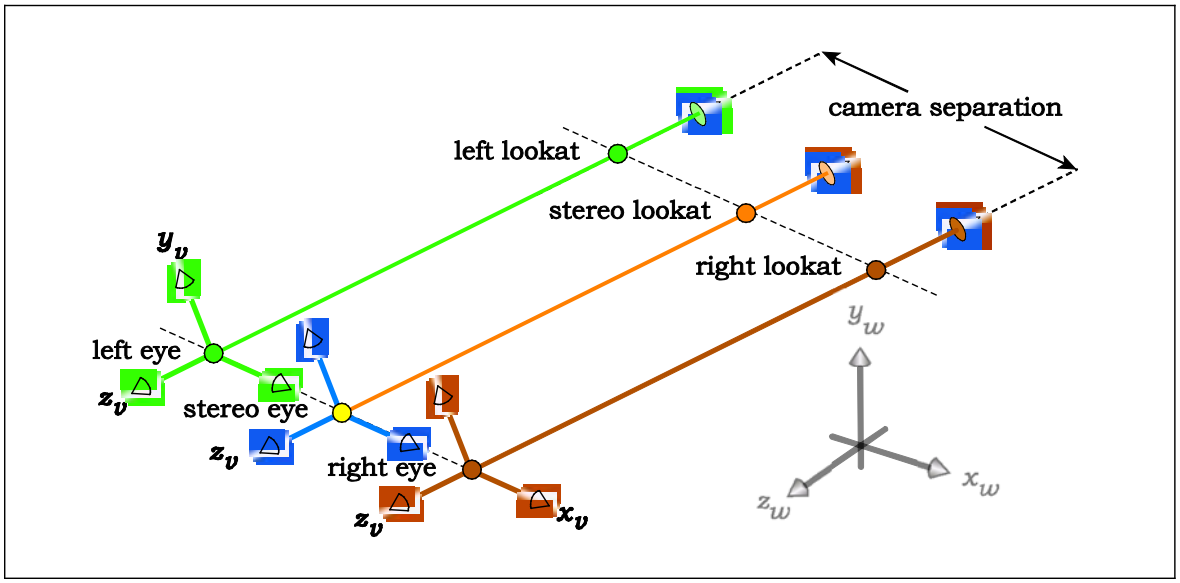
Camera

- Requires non symmetric camera frustum
- We need to change the symmetric frustum to an asymmetric function
  - Translate the window over the view plane in the x direction by half the camera separation

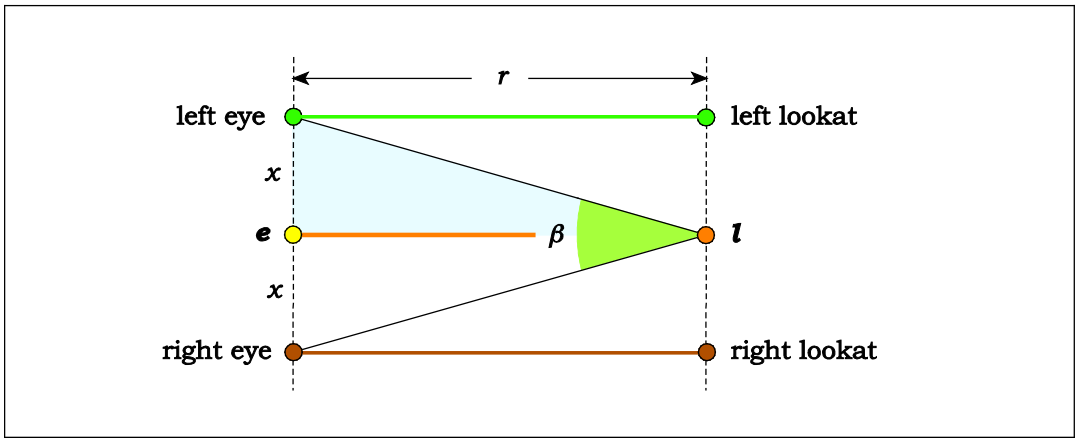


- Left camera - translate in positive direction
- Right camera – translate in negative direction

Camera



- $R = || e - l ||$
- $X = r \tan(\beta / 2)$



Displaying and Viewing

- Various techniques to display the correct image to each eye
  - Shutter glasses
  - Unassisted
  - Stereoscope
  - Anaglyph
- Shutter glasses
  - Glasses synchronized with computer display
  - Limited viewers

Displaying and Viewing

- Unassisted
  - Side-by-side on computer screen or print
  - Difficult to fuse images

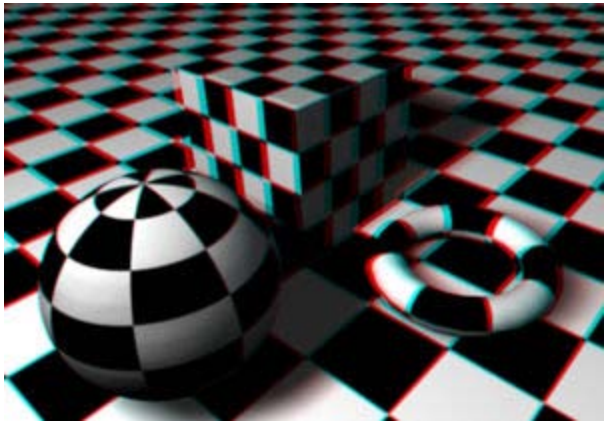
- Parallel viewing vs transverse viewing
  - Parallel viewing limited to 5 cm across
  - Transverse no size restrictions

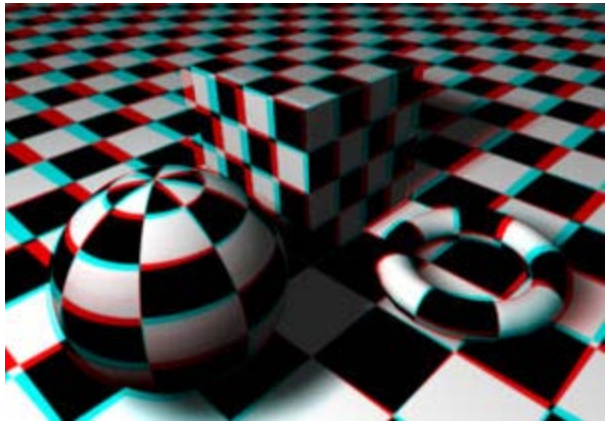
Displaying and Viewing

- Stereoscope
  - Uses parallel viewing
  - model determines max image size
- Anaglyph projection
  - Projectors with polarized filters
  - Viewers wear passive polarized glasses
  - Mass viewing (movie theaters)
  - Special hardware required

Displaying and Viewing

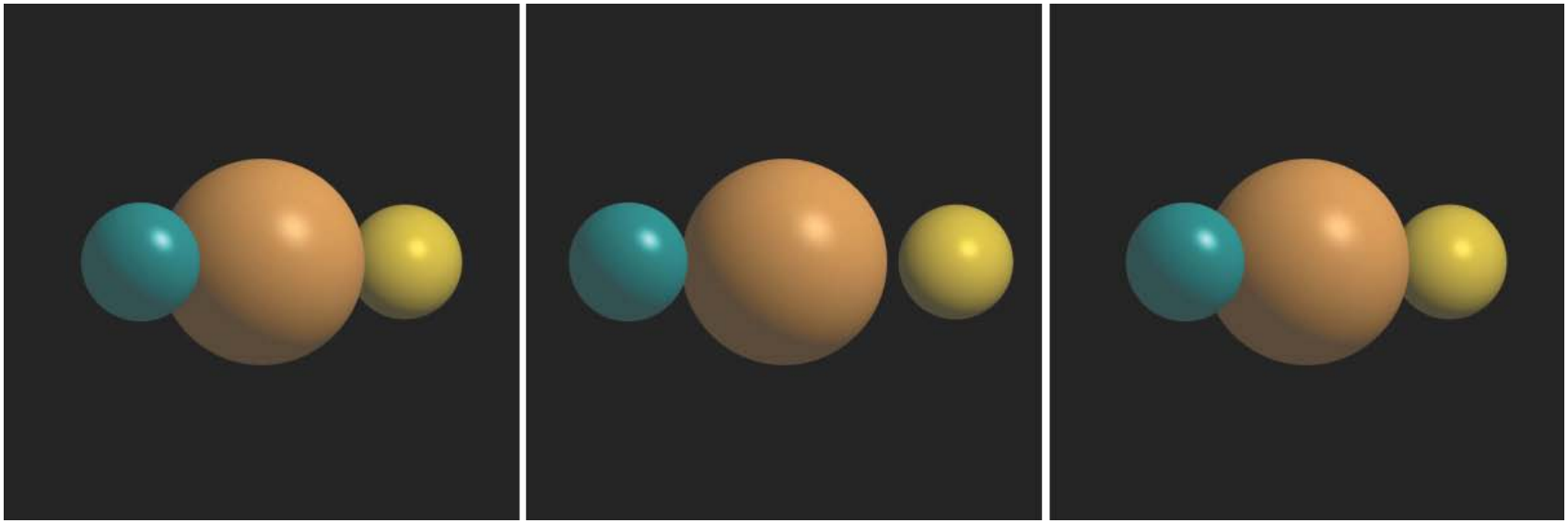
- Anaglyph images
  - Two color filtered images combined together
    - Red and Cyan
  - Images offset to create depth effect

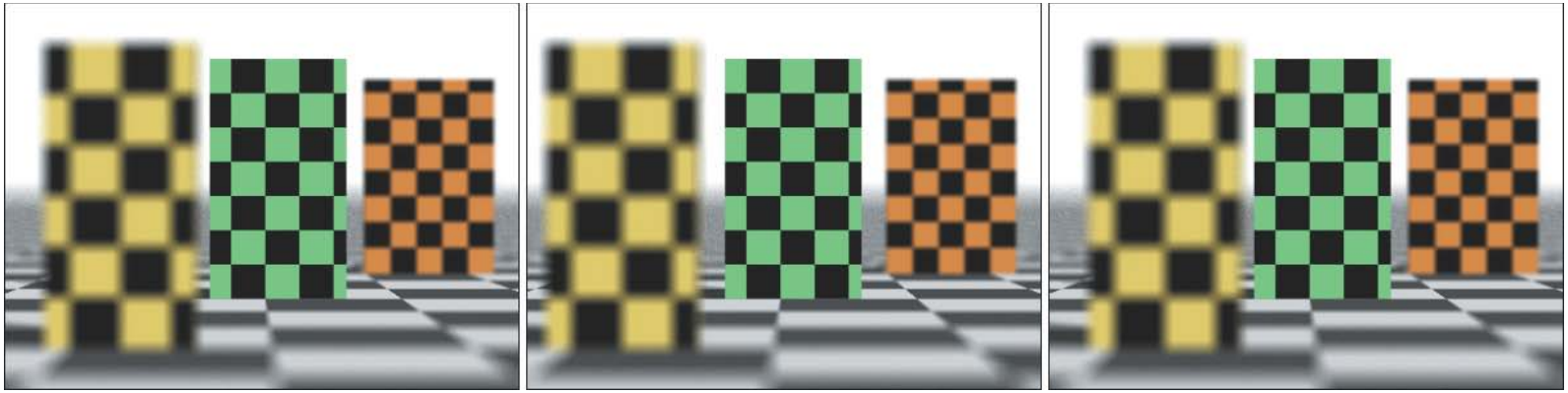


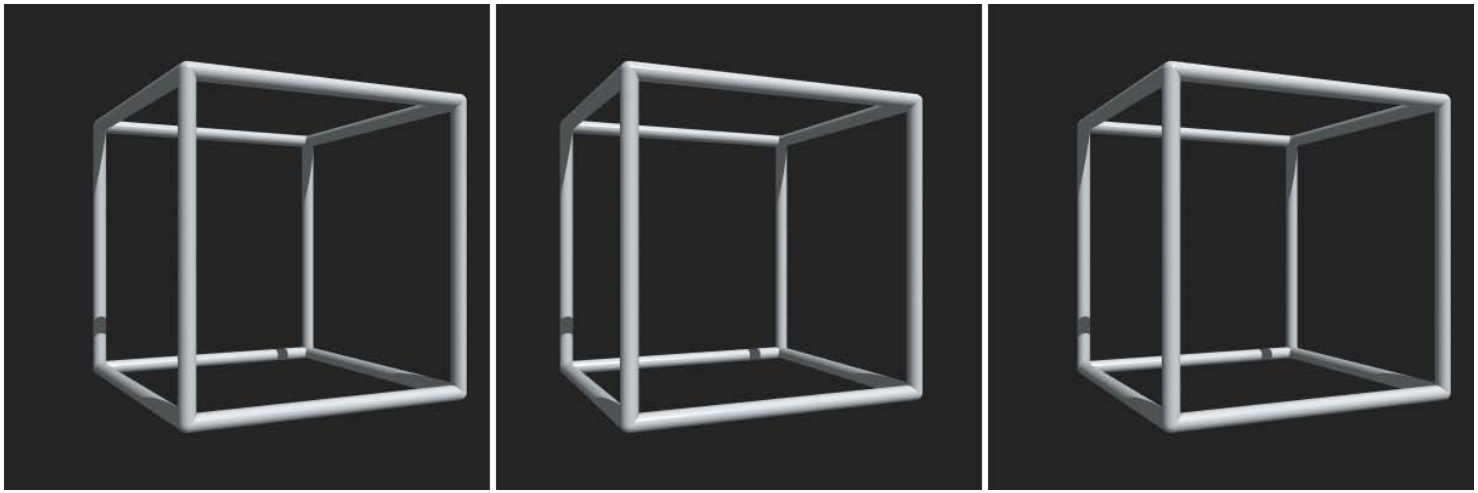


- http://www.captain3d.com/stereo/html/tutorial.html

Results







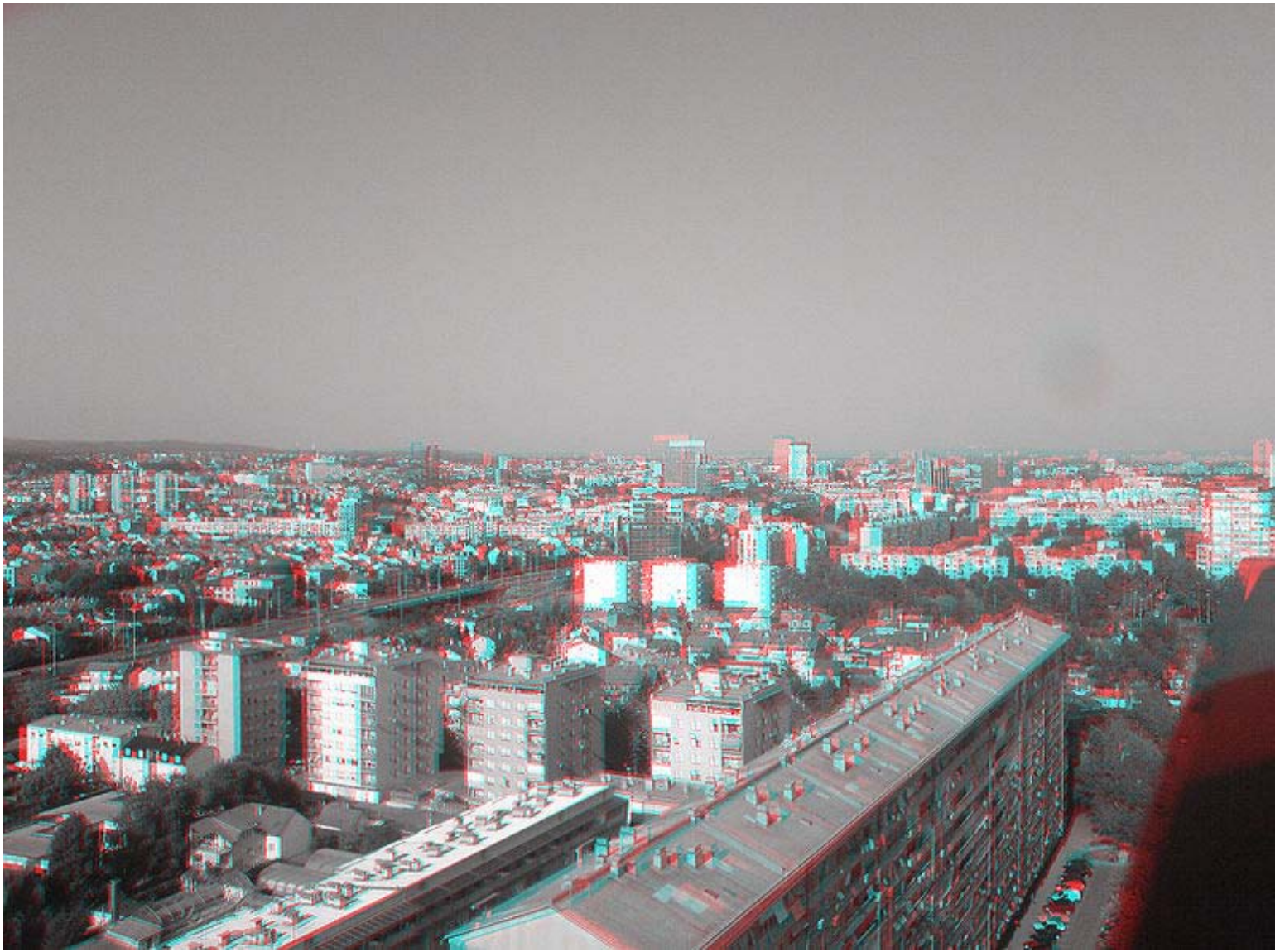
Results

- http://www.captain3d.com/stereo/html/tutorial.html

Results

- http://upload.wikimedia.org/wikipedia/commons/d/d7/Art_Institute_of_Chicago_Lion_Statue_%28anaglyph_stereo%29.jpg

Results

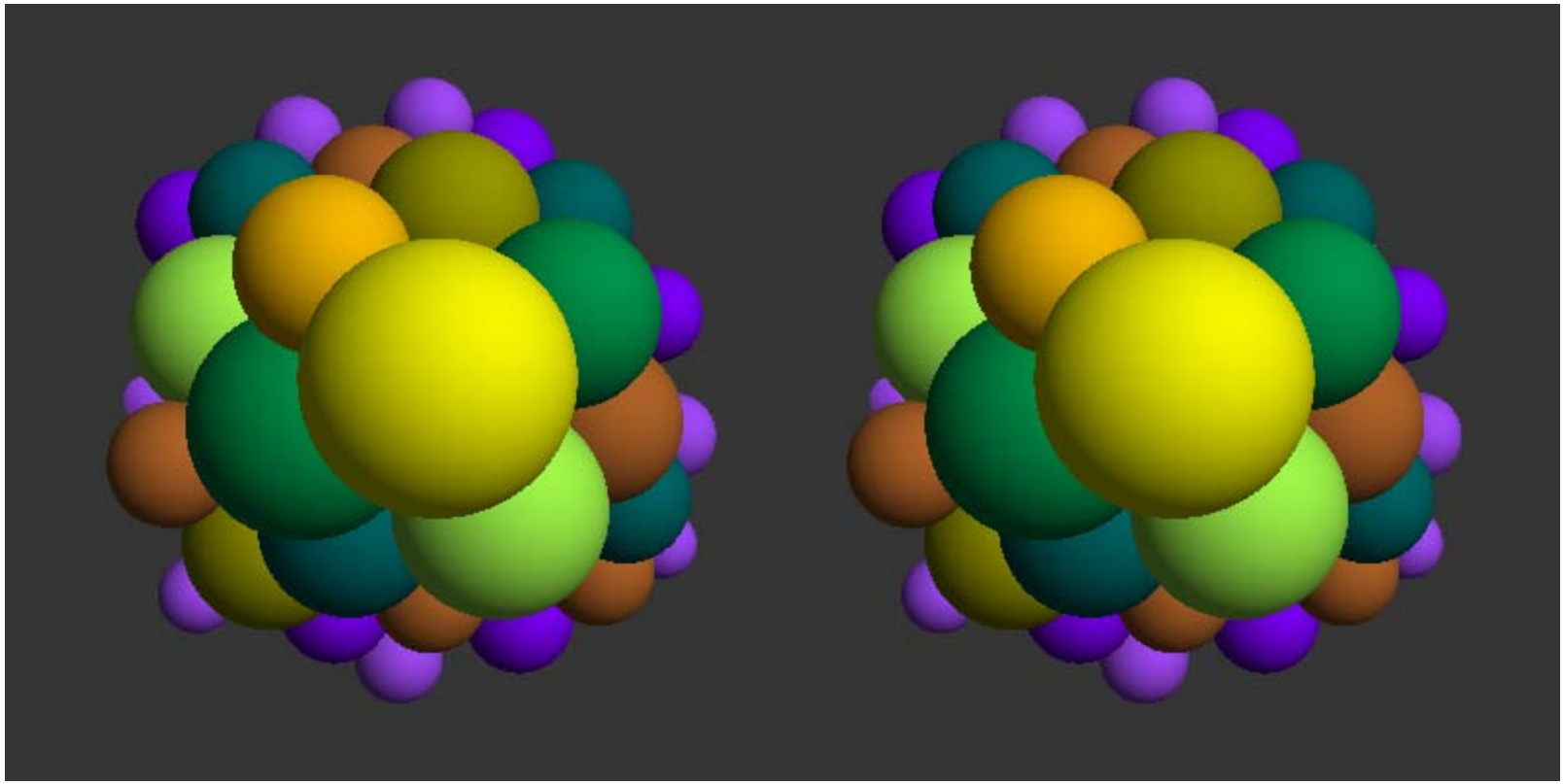


- http://en.wikipedia.org/wiki/File:3D.jpg

Results

- http://en.wikipedia.org/wiki/File:Dusk_on_Desert.jpg

Results



Discussion

- Questions?

References

- http://www.raytracegroundup.com
- Suffern, Kevin (2007). Ray Tracing from the Ground up. Pp. 197-216 Wellesley, MA: A K Peters, Ltd.
- http://local.wasp.uwa.edu.au/~pbourke/miscellaneous/stereographics/
- http://www.captain3d.com/stereo/html/tutorial.html