Lens Effects

York University CSE 4431
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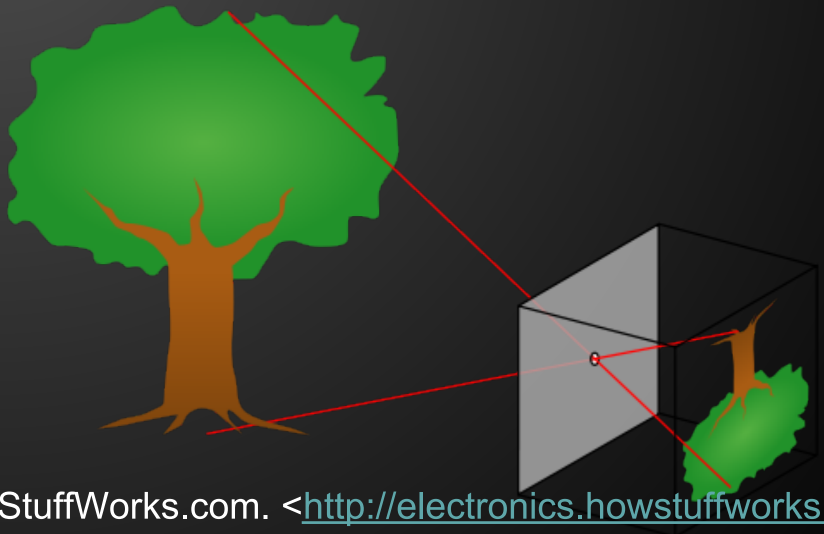
Lens Effects in 3D renderings

To talk about lens effects in 3D renderings we must first understand how they're produced in the real world

Ebbesen, Bill. "File:Photographic lenses front view.jpg." 3 June 2010. WIkipedia. 23 March 2012 <http://en.wikipedia.org/wiki/File:Photographic_lenses_front_view.jpg>.

Cameras: how do they work?

- Simplest camera is the pinhole
  - Photosensitive paper placed on one side of a light-proof box
  - Each light ray that makes it through the hole maps to one point on the paper (ideally)
  - Pinhole acts as both lens and aperture
  - Infinite focal length



"How does a pinhole camera work?" 01 April 2000. HowStuffWorks.com. <http://electronics.howstuffworks.com/question131.htm> 23 March 2012.

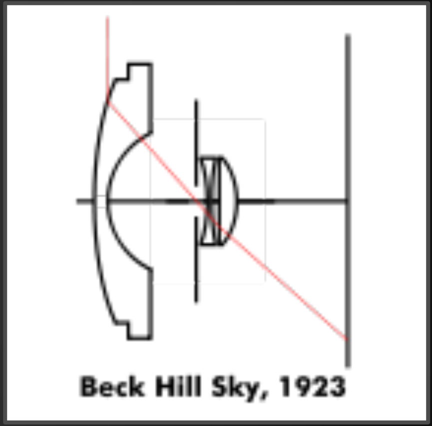
Cameras: how do they work?

- Separate lenses added to change the way light enters the aperture
  - Can change the field of view with different lens shapes
  - Must also deal with focus
    - Light now converges inside the box (camera body)
    - For concave lens photosensitive medium (sensor) must be at focal length
    - For convex lens subject must be at focal length
  - Bring different objects in and out of focus by changing the distance from the lens to the sensor

http://en.wikipedia.org/wiki/Focal_length

Lens shapes

- Allows sensor to capture different portions of the environment
- Fisheye lens
  - Compresses up to 180° onto the sensor
- Macro Lens
  - Allows actual image size (image on the sensor) to be the same size, or bigger than, the subject

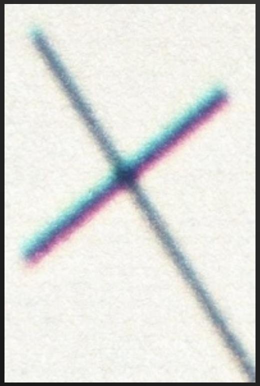


Chin, Paul. "File:Fisheye-text.svg." 22 November 2010. Wikipedia. 23 March 2012 <http://en.wikipedia.org/wiki/File:Fisheye-text.svg>.

http://en.wikipedia.org/wiki/Camera_lens

Light artifacts

- The modern camera, having multiple lenses and an adjustable aperture, produces artifacts and aberrations based on the way light bounces inside the camera
  - Chromatic aberration
  - Bokeh
  - Lens flare



van Walree, Paul. "Chromatic aberrations." toothwalker.org. 24 March 2012 <http://toothwalker.org/optics/chromatic.html>.

Ye, Jiawei. "Bokeh." toothwalker.org. 24 March 2012 <http://toothwalker.org/optics/bokeh.html>.

Kartapranata, Gunawan. "File:Lens Flare at Borobudur Stairs Kala Arches.JPG." 4 February 2010. Wikipedia. 23 March 2012 <http://en.wikipedia.org/wiki/File:Lens_Flare_at_Borobudur_Stairs_Kala_Arches.JPG>.

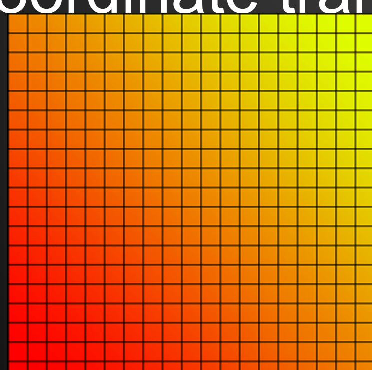
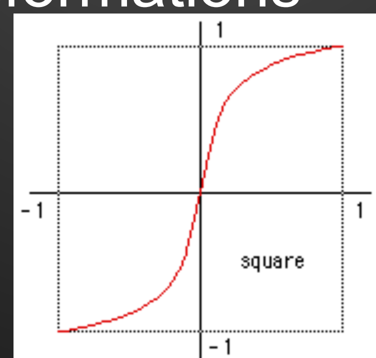
http://toothwalker.org/optics.html

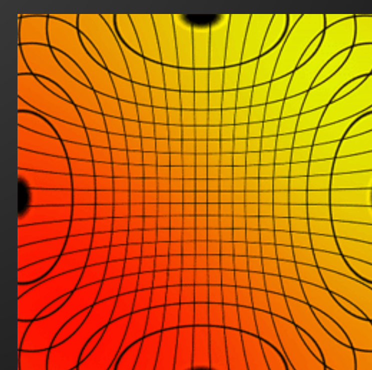
Computer generated images

- Everything is always in focus, projection is under total control
  - Boring!
- We introduce aberrations, artifacts, and warping for realism and artistic effect

Perspective effects

- Most basic effect is coordinate transformations
  - Changing the shape of the frustum changes the amount of geometry seen, and skews the coordinate system
    - Built into OpenGL: `gluPerspective()`
  - Achieve different "lens shapes" with nonlinear coordinate transformations



http://paulbourke.net/miscellaneous/lenscorrection/

Focus effects

- Depth of field can be achieved by raytracing
  - Trace multiple rays per pixel at different angles
  - Average results of samples
- Fake it for real-time applications
  - http://encelo.netsons.org/2008/04/15/depth-of-field-reloaded/
    - Render the scene into a buffer
    - Apply blur filter to the buffered image
    - Combine blurred image into final based on fragment's Z value
  - http://paulbourke.net/miscellaneous/blur/
    - Render scene from multiple angles
    - Overlay on top of each other

Light effects

- Lens flares could be produced using a physically-based camera model
    - Model lens system and raytrace, accounting for exposure
    - Accurately produces all effects simultaneously (perspective, focus & light)

Brian A. Barsky, Daniel R. Horn, Stanley A. Klein, Jeffrey A. Pang, Meng Yu. "Camera Models and Optical Systems Used in Computer Graphics: Part I, Object-Based Techniques." Kumar, Vipin. Computational science and its applications, ICCSA 2003. Berlin: Springer-Verlag, 2003. 246-255.

Effects with GLSL

- Perspective
  - Use vertex shader to transform coordinates
- Depth of Field
  - Render into frame buffers, blur, combine
- Chromatic aberration
  - Cube-mapped geometric lens
    - Use different texture coordinates for r/g/b
  - Whole scene
    - Transform perspective differently for r/g/b, render into buffers, combine
- Lens flare
  - Calculate where flares should be, render sprites