Lecture #11 NBA 6120 Donald P. Greenberg September 30, 2015

What is Virtual Reality?

• A term used to describe a computer generated environment which can simulate the perception of PRESENCE.

• A person immersed within this virtual world can manipulate objects, interact with the environment, and explore the virtual world in the same perceptual way as one interacts with the physical world.

Oculus Rift



Why did Facebook invest \$2 billion in Oculus Rift?

Microsoft's Hololens



Microsoft buys Minecraft



Why is Microsoft building its Hololens? Why did it buy Minecraft?

Magic Leap



Google

Why is Google (and Andressen / Horwitz) investing \$500+ million in Magic Leap?

Oculus Rift DK2



HTC and Valve's SteamVR Vive



HTC and Valve's SteamVR Vive

- Introduced this month at the Game Developers Conference.
- This device will be at the high end of the game market with better tracking technology and higher resolution.

John Carmack announces deal for bringing both Minecraft (MSFT) and Netflix to both Gear VR and Oculus VR.



Minecraft was bought by MSFT for \$2.5B, and Netflix is responsible for 37% of internet traffic.

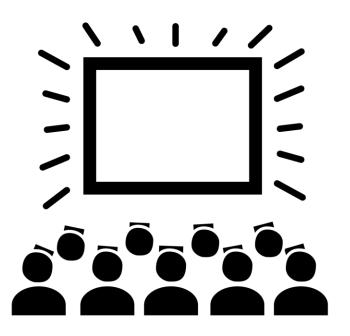
Why is VR different than other modes of watching images and video?

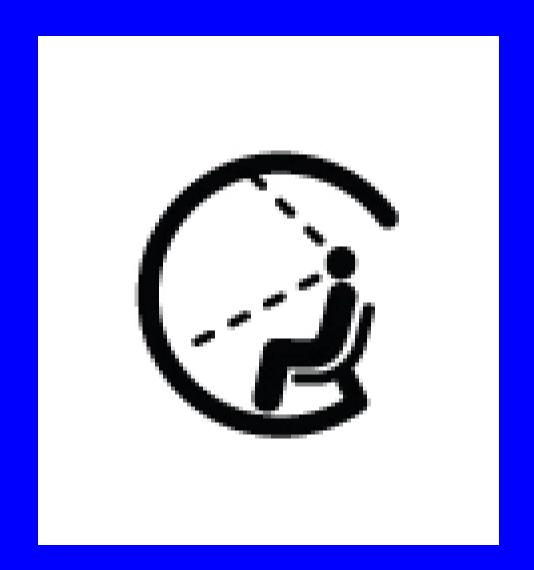
Human in the Loop

- Abstract Interpretation
- Viewing a Picture on Television
- Cinema Viewing
- Presence









Depth Perception from 2-D Images

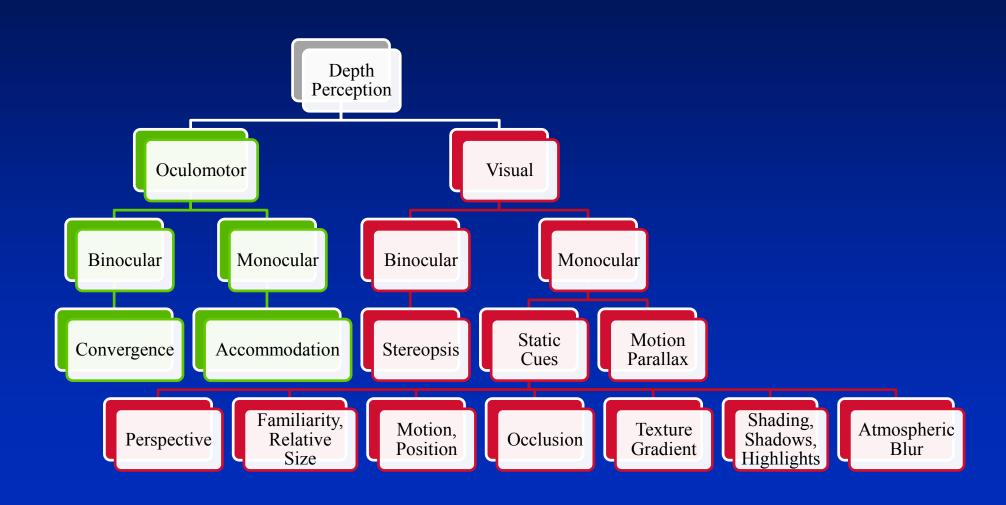
- Monoscopic
- Stereoscopic

Paris Street, Rainy Day 1877

Caillebotte

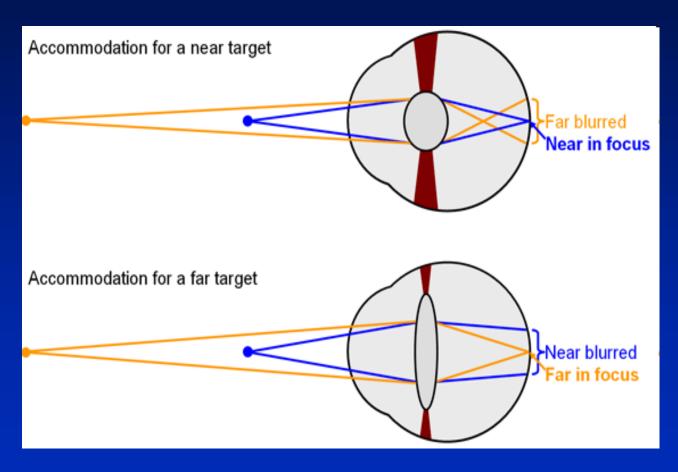


Human Depth Perception



Monoscopic Depth Cues

- Perspective
- Depth from Motion, Relative Size, Position, Familiarity
- Occlusion
- Texture Gradient
- Parallax from Motion
- Shadows and Specular Highlights
- Atmospheric Blur
- Accommodation

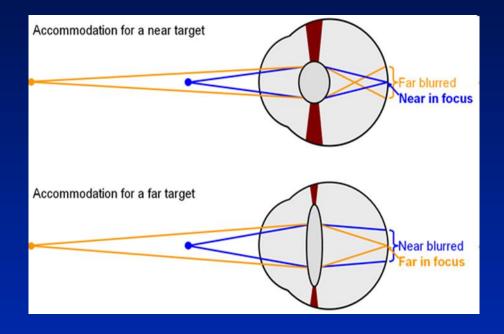


Note change in lens shape

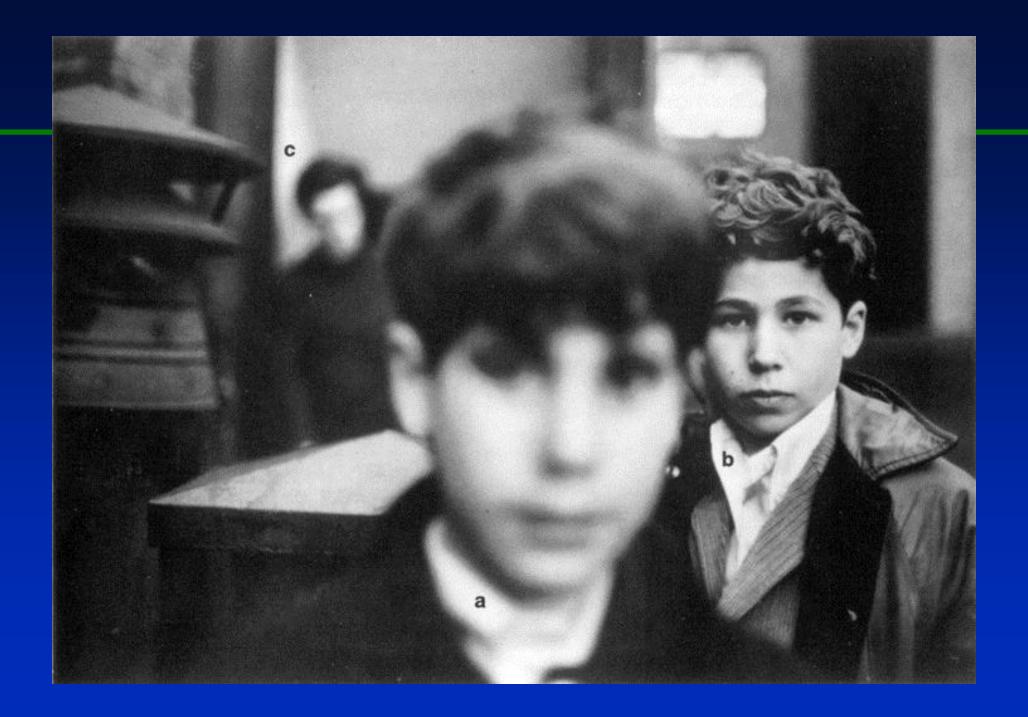
Accommodation

• This is the process by which the vertebrate eye changes optical power to maintain a clear image or focus on an object as its distance varies.

Accommodation



The reflex can be controlled but cannot be 'felt' Accommodation amplitude declines with age

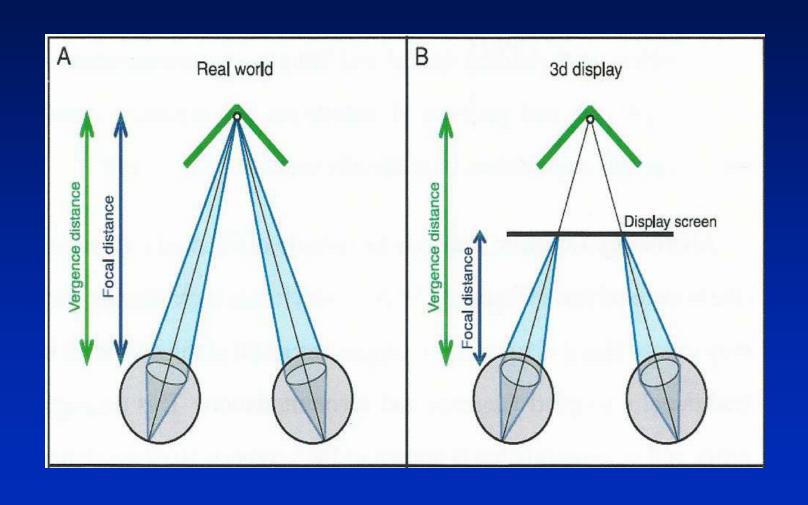


Vergence

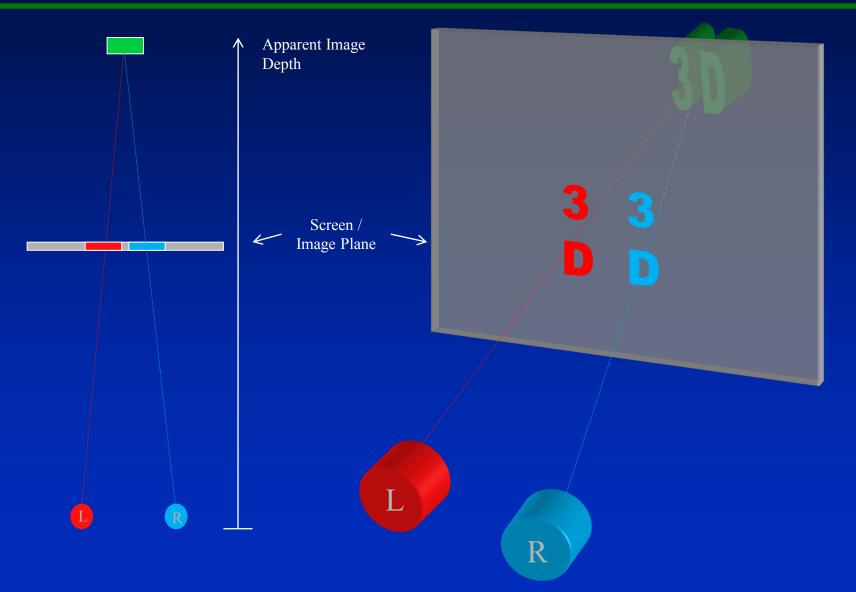
• The simultaneous movement of the pupils of the eyes toward or away from one another during focusing.

• This measure of the convergence or divergence of a pair of light rays is defined as vergence.

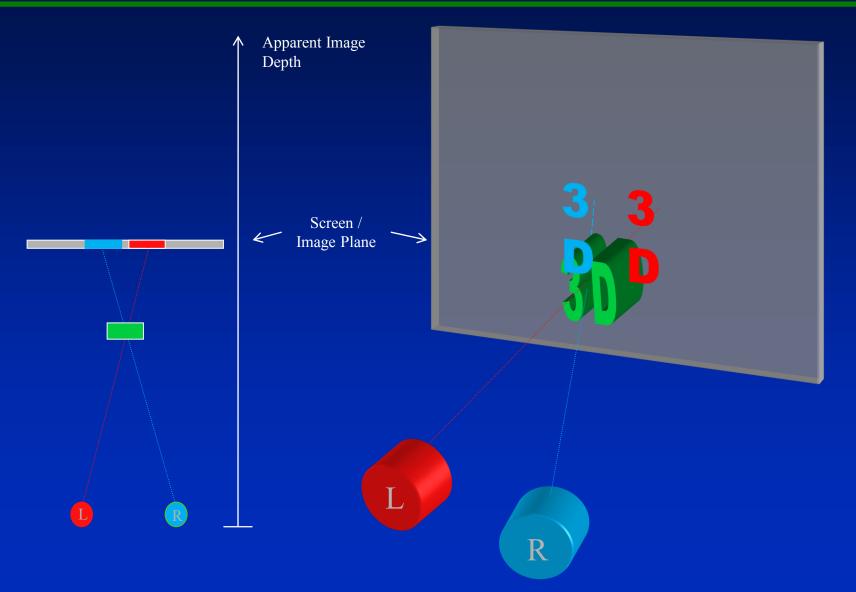
Diagram of Vergence



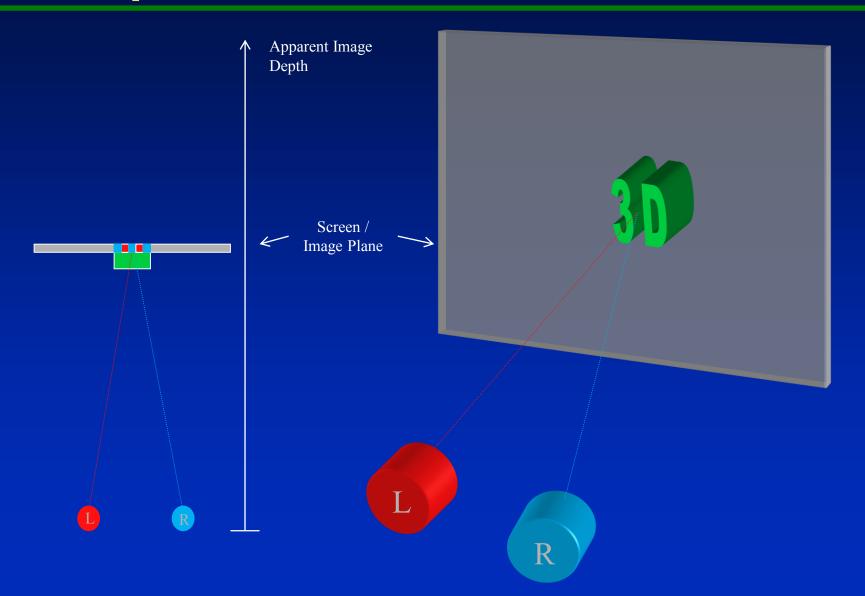
Stereoscopic Vision: Behind The Screen (Concave)



Stereoscopic Vision: In Front Of The Screen (Convex)



Stereoscopic Vision: At The Screen



Vergence Accommodation Conflict

- Computer and projection displays present images on a single surface but have a focal distance (blur on the retina) which may be in front of or behind the screen
- The inability to fuse the binocular stimuli causes discomfort and fatigue to the viewer
- Viewers can be trained, and the discomfort can diminish with practice

Understanding the Human Visual System

Components of the Human Eye

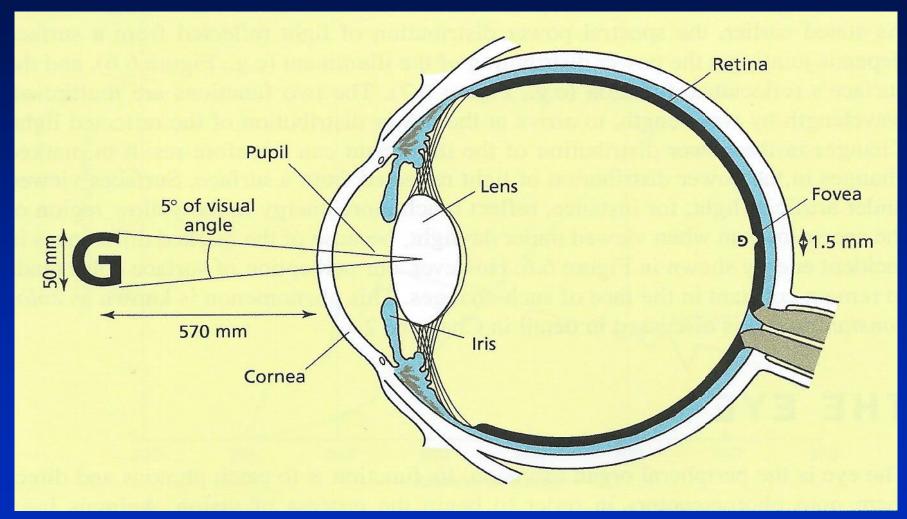
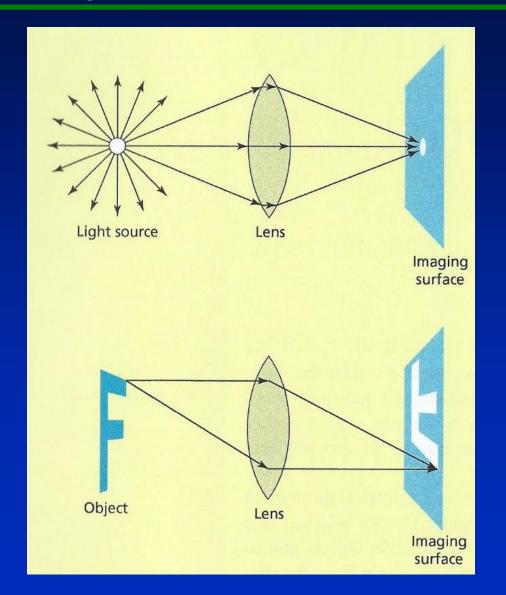
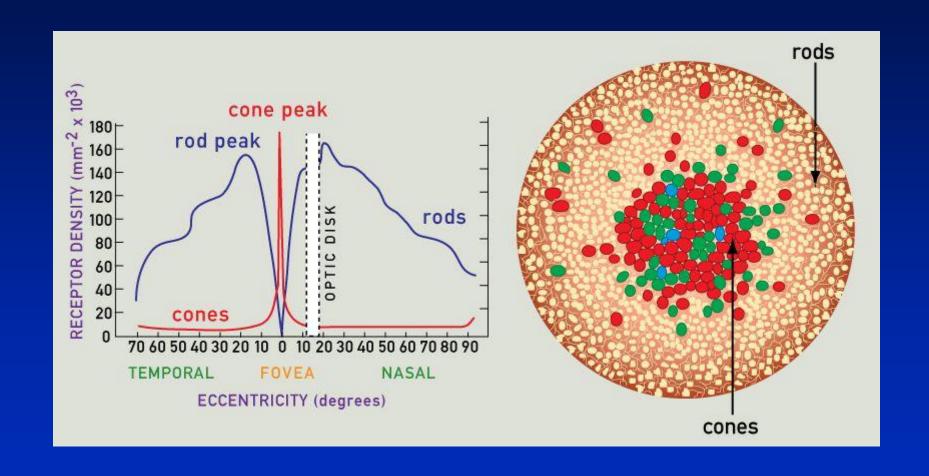


Image Formation by Lenses





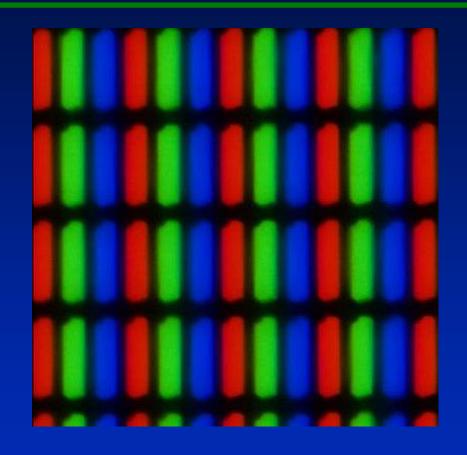
Resolution of the Human Eye

- Humans can tell visual details at distances larger than 0.3 arc minutes
- The Field of View (FOV) of the human eye can be generously estimated as 120 by 90 degrees

Resolution of the Human Eye

- (120 degrees x 60 arcminutes / degree x 1 pixel / 0.3 arcminutes) x (90 degrees x 60 arcminutes / degree x 1 pixel / 0.3 arcminutes)
- 431,568,000 pixels; 432 MegaPixels. A 1080p display is 2.1 megapixels.

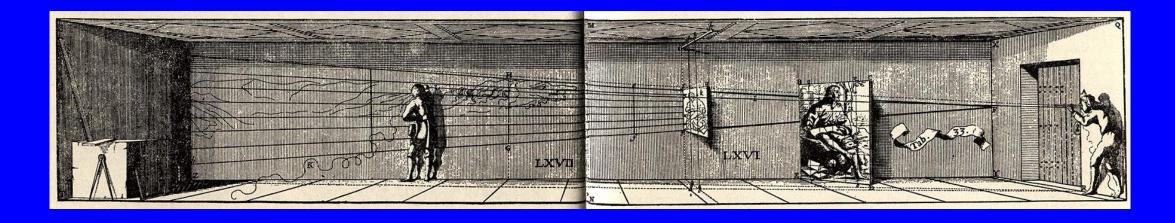
Samsung AMOLED Displays



Standard LCD RGB Display

PenTile Display

Distorted Images



Jean-Francois Niceron. *Thaumaturgus opticus*...(Rome, 1646), illus. 25.

The projection of a screen or grid in anamorphic perspective makes the transfer of a representation possible.



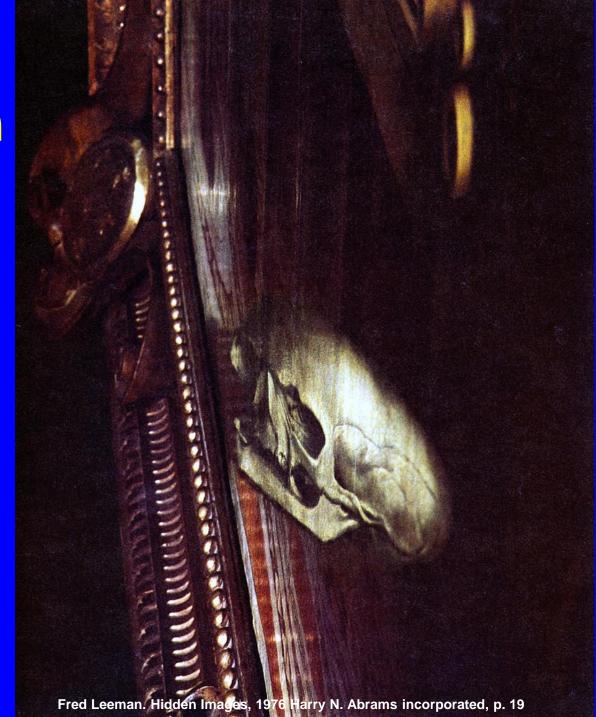
Erhard Schon. Picture puzzle: Out, You Old Fool c. 1535. Fred Leeman. Hidden Images, 1975, Harry N. Abrams.

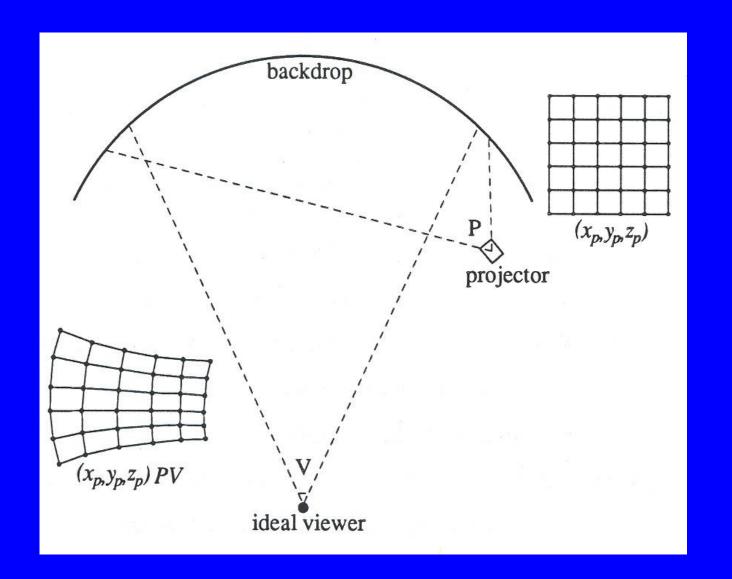
Hans Holbein The Ambassadors



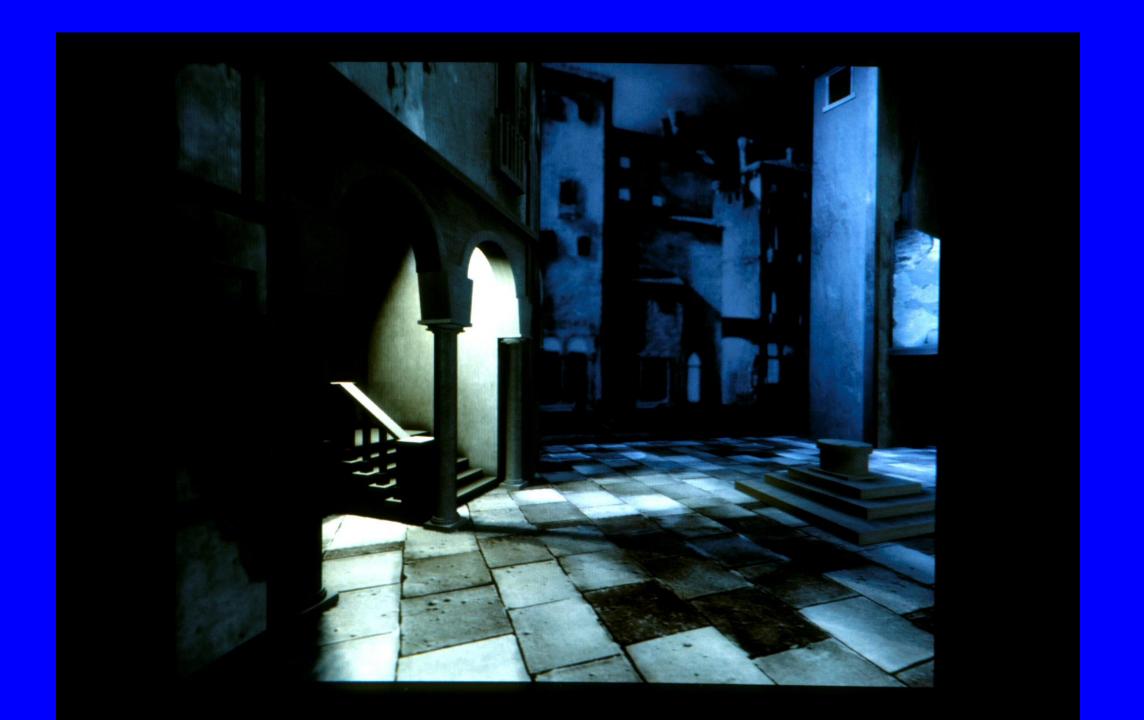
Google Art Project: http://www.googleartproject.com/museums/nationalgallery/the-ambassadors

Hans Holbein









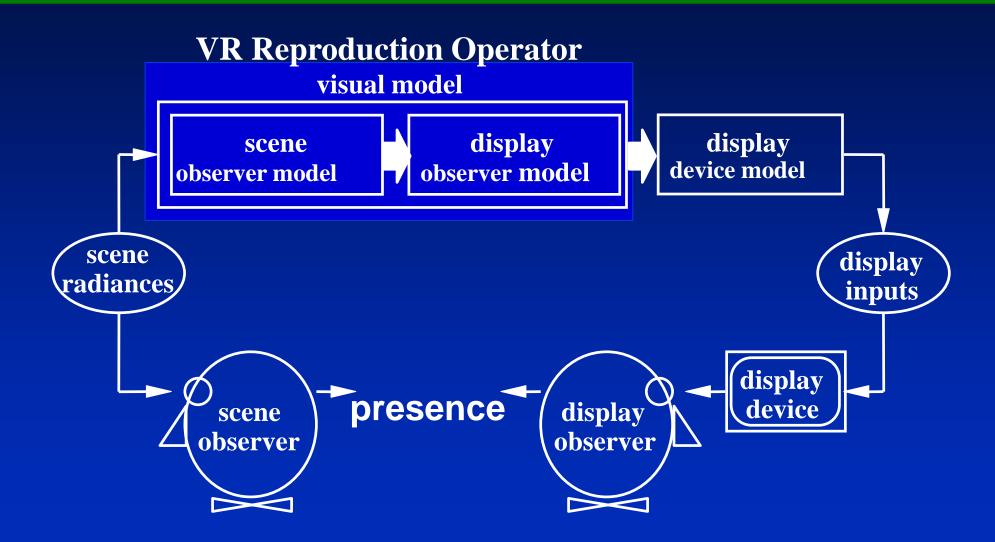
Truck Art



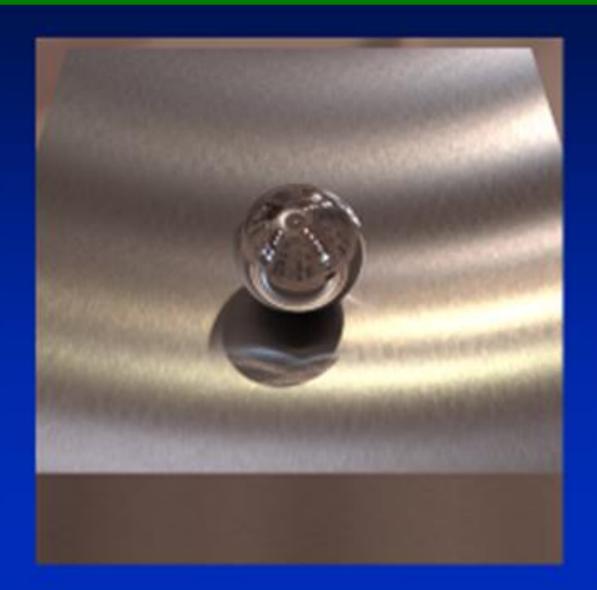
Julian Beever - Chalk Drawings



The goal of VR reproduction operators



Stainless Steel Simulation



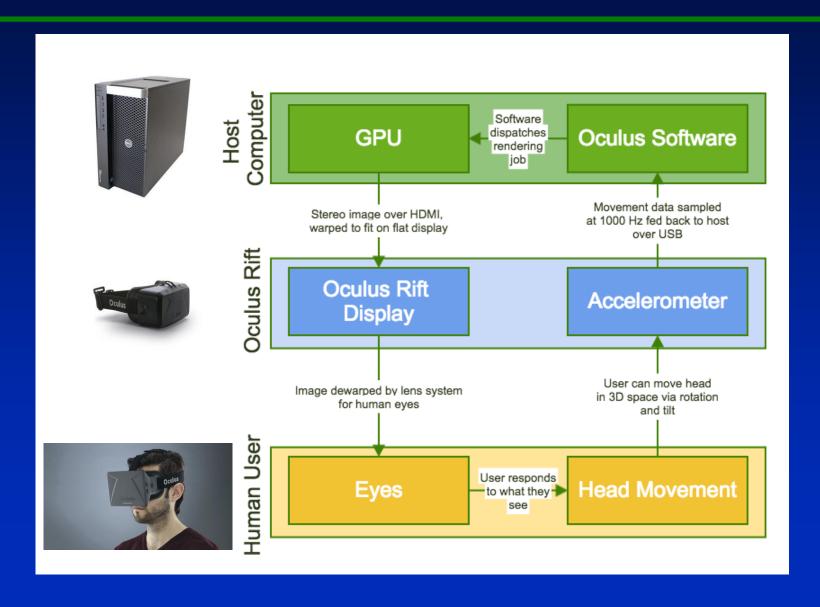


Eames Chair

Pixar's Renderman







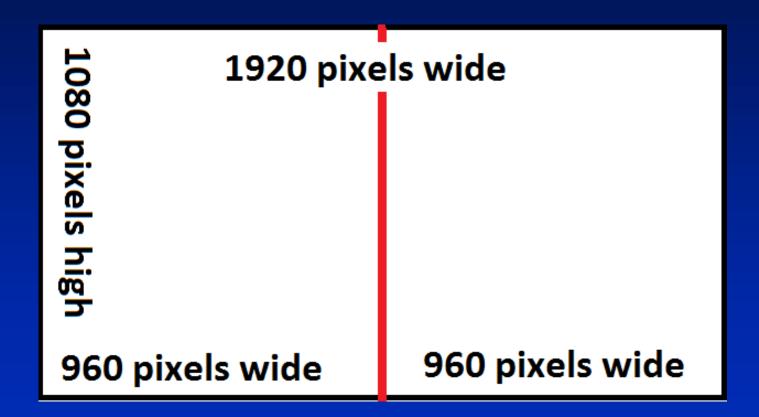
Components

Accelerometers and logic board

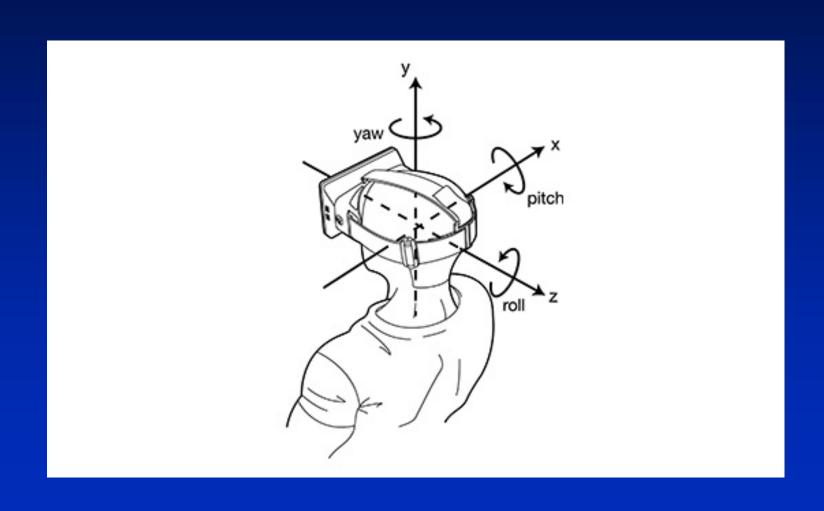
Flat 1080P AMOLED-Display



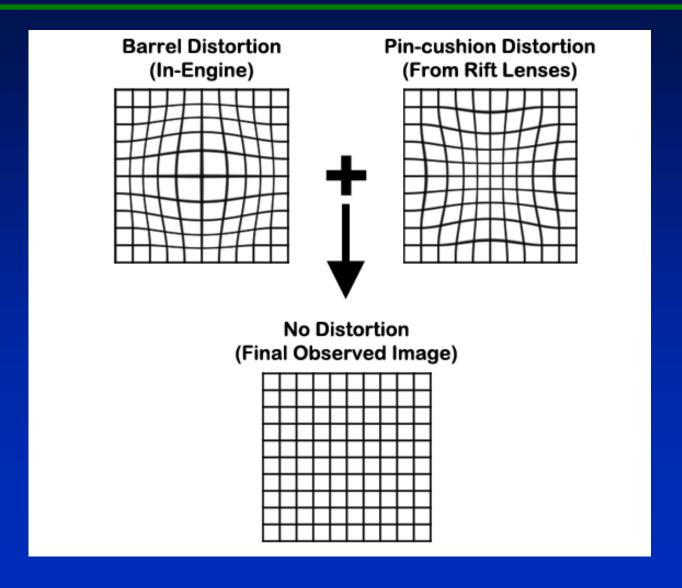
Lenses



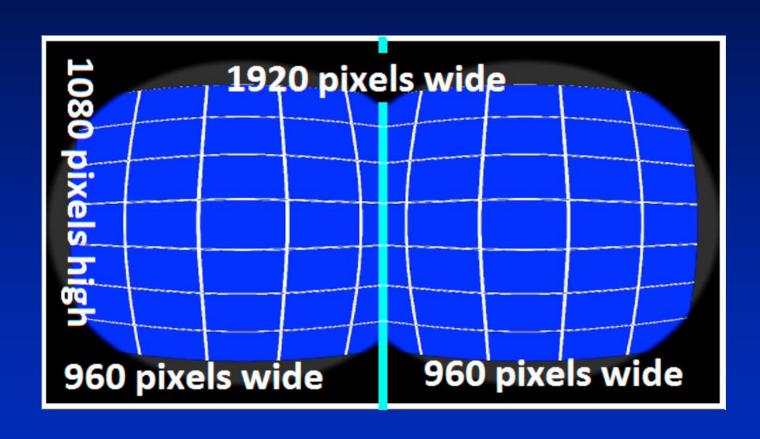
Angular Rotation



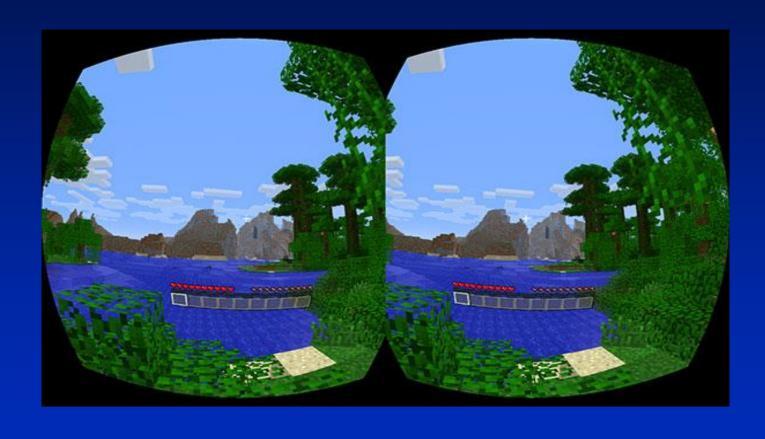
Distortion Strategy



Distorted Image



Distorted Image



Distorted Image



'Oculus Ready' PC Program



> \$1,000 including computer

Requirements for "PRESENCE"

- Understanding the Human Visual System
- Improving the Device Characteristics
- System Performance

Virtual Reality

What is necessary to make virtual reality a reality?

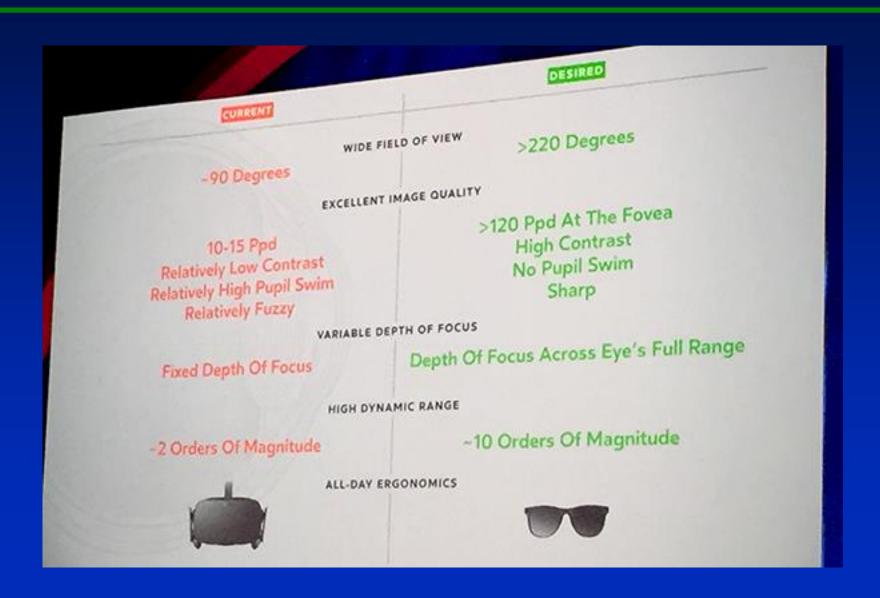
Crossing the VR Chasm

- Device Characteristics
 - Display resolution
 - Field of view
 - Color Gamut
 - Dynamic range
- View Location and Direction
 - Position accuracy
 - Sensor Response
 - Gaze direction

Crossing the VR Chasm

- Dynamic Motion
 - Refresh/update
 - Latency
 - Rendering computation
 - Bandwidth
 - Pixel switching time
- Model Complexity
- Dynamic Data Capture
- D-tethering
- Economy

Current vs. Desired Characteristics



Crossing the VR Chasm

- See your hands
- Eye-to-eye contact
- SOCIAL ACCEPTANCE

End