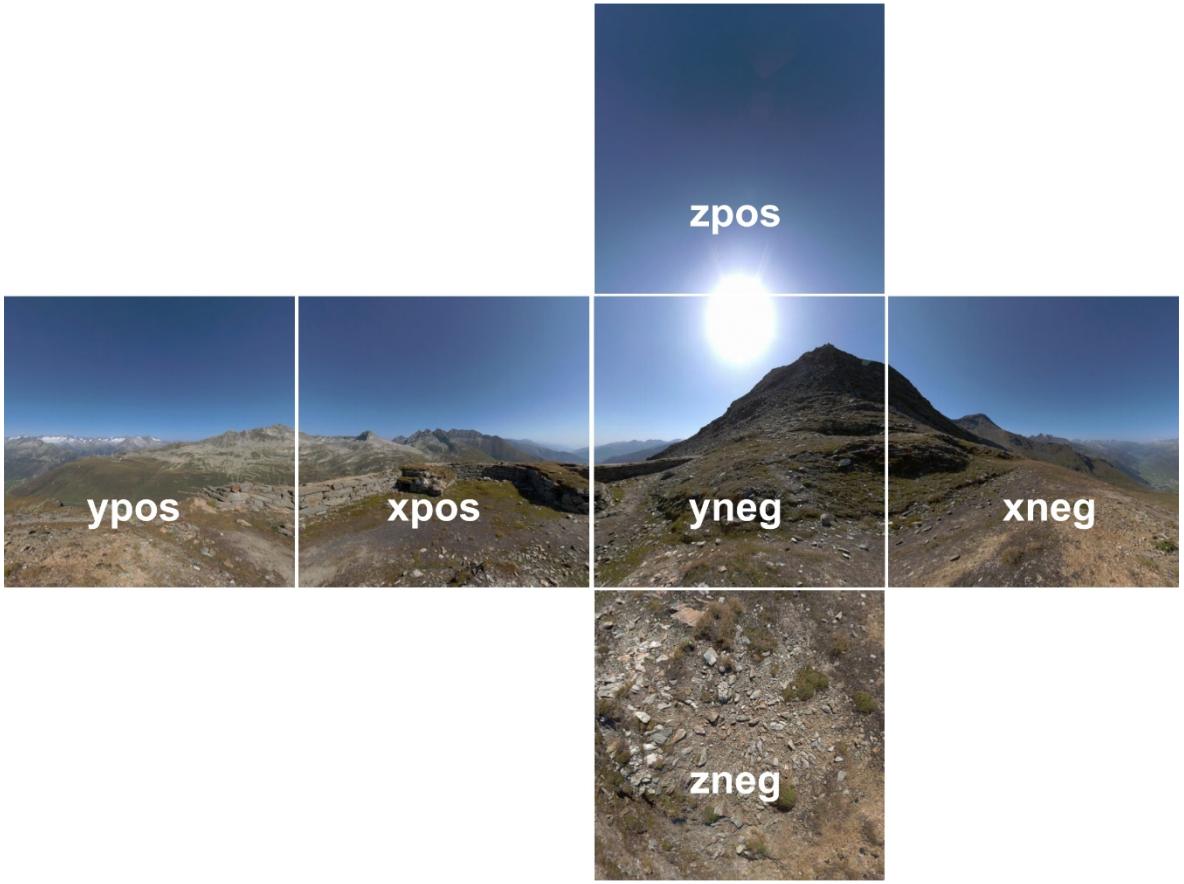
CSE 190: Virtual Reality Technologies

LECTURE #4: THE IDEAL VR DISPLAY

VR Project

This week: skybox



The Ideal VR Display

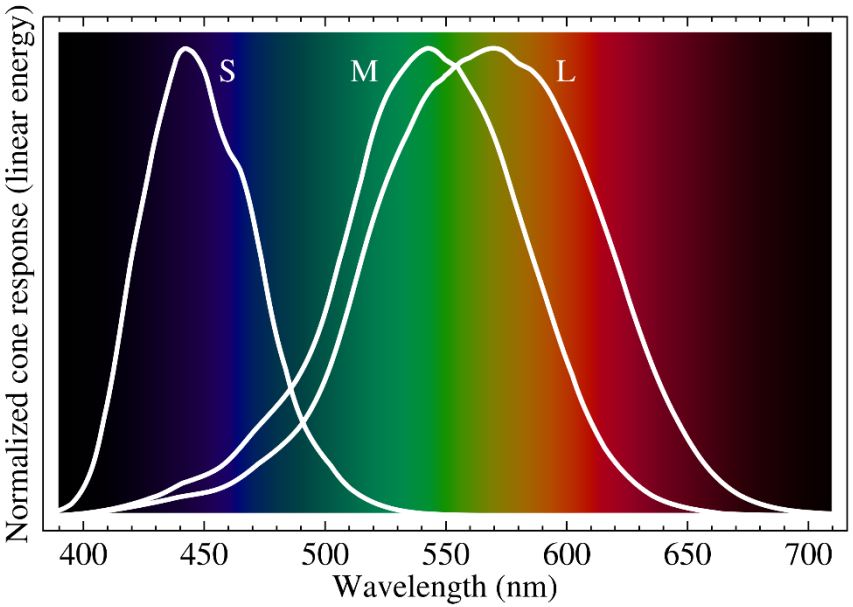
Colors

The human eye distinguish about 10 million colors

But not evenly distributed in red, green and blue

32 bits can store 2 billion colors

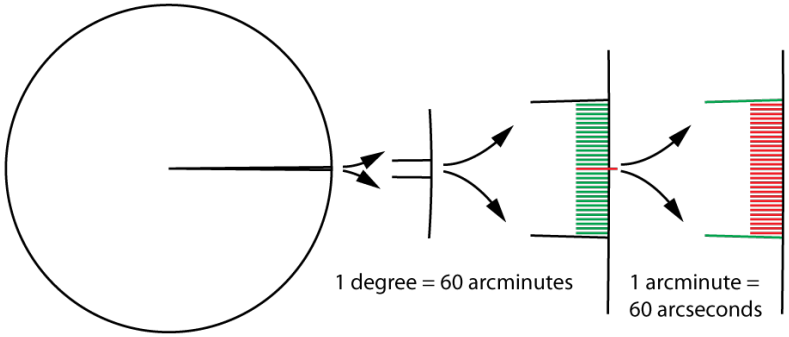
→ 32 bits storage per pixel

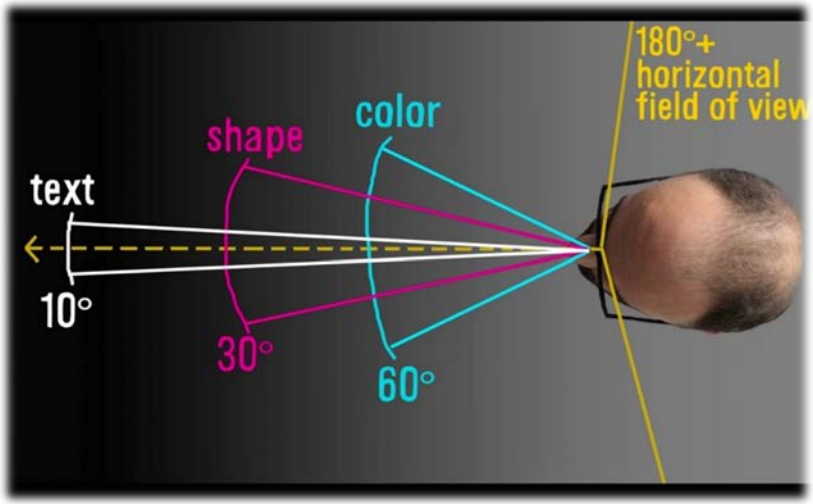


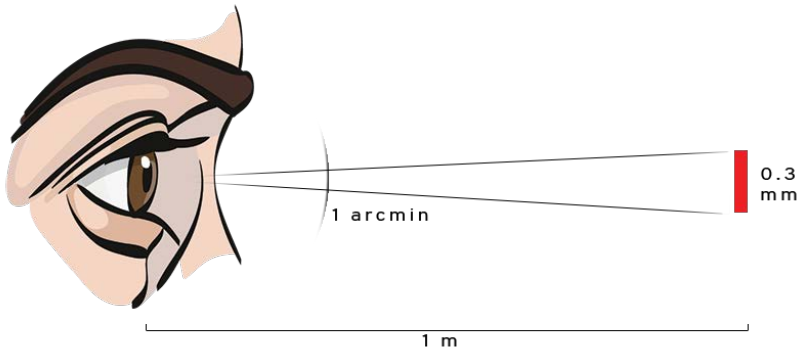
Spatial Resolution

~150 pixels/degree in center of field of view

Less towards edge







Retina VR Display

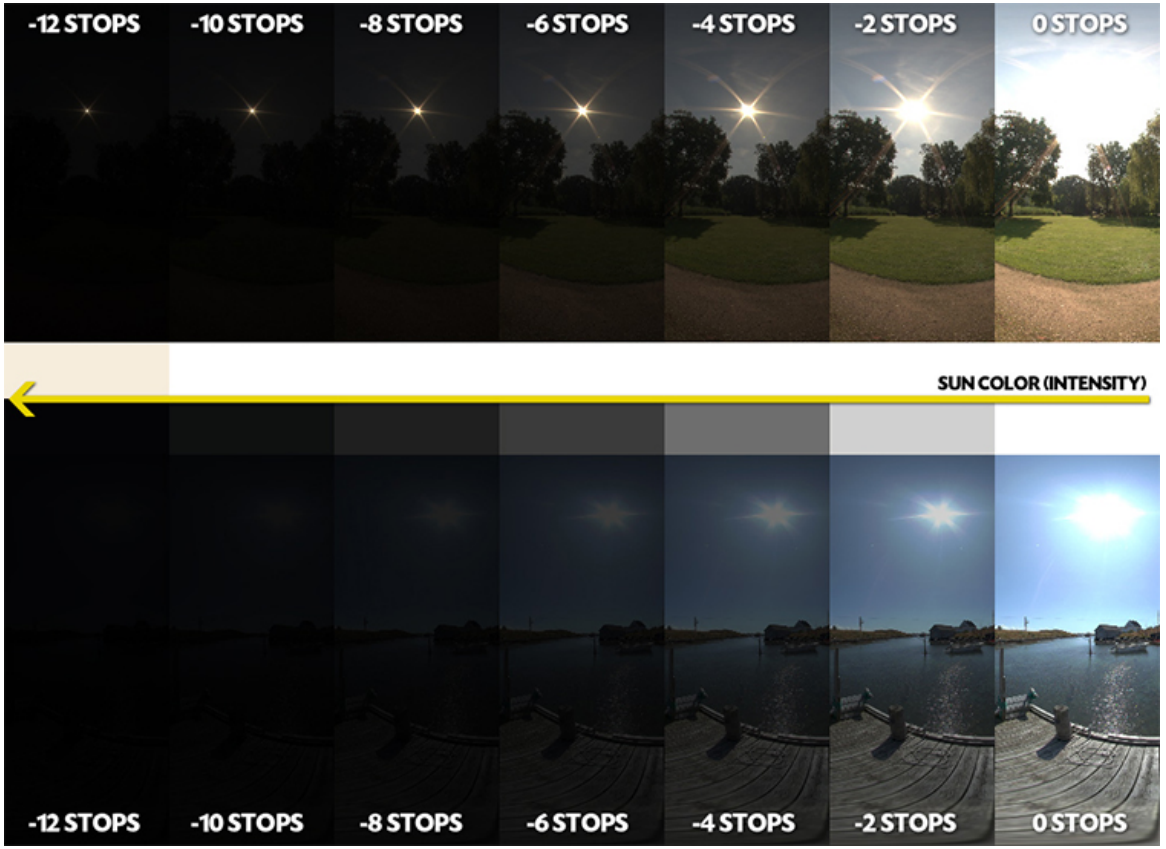
- Resolution per eye:
  - 145° x 135° field of view at 150 pixels/degree resolution

    → 21,750 x 20,250 pixels = 440 Mpixels
- For two eyes (stereoscopic vision):
  - 2 x 440 Mpixels = 880 Mpixels

Temporal Resolution

~60-150 Hz (varies with brightness)

Dynamic Range



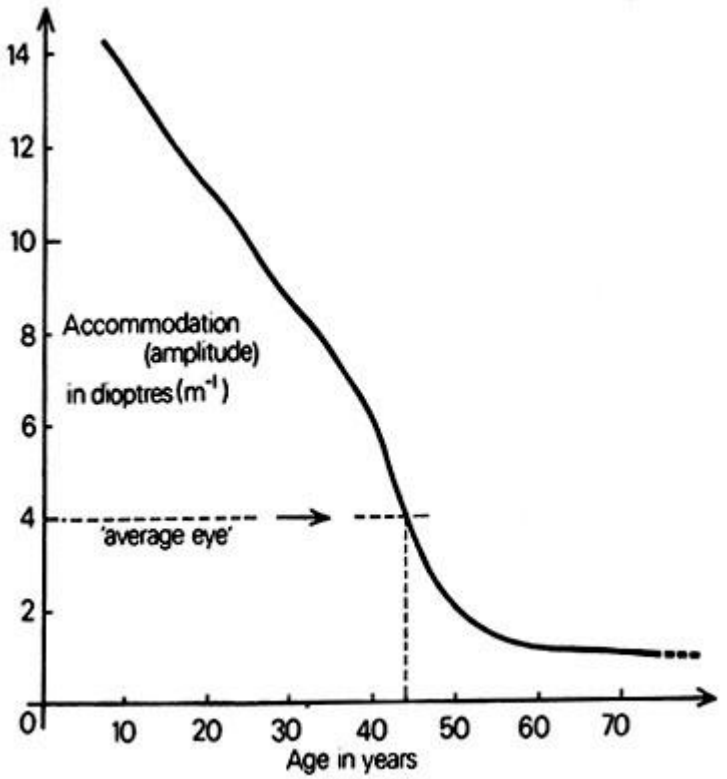
100:1 (retina), 1 billion:1 (with iris)

Accommodation Range

Age dependent

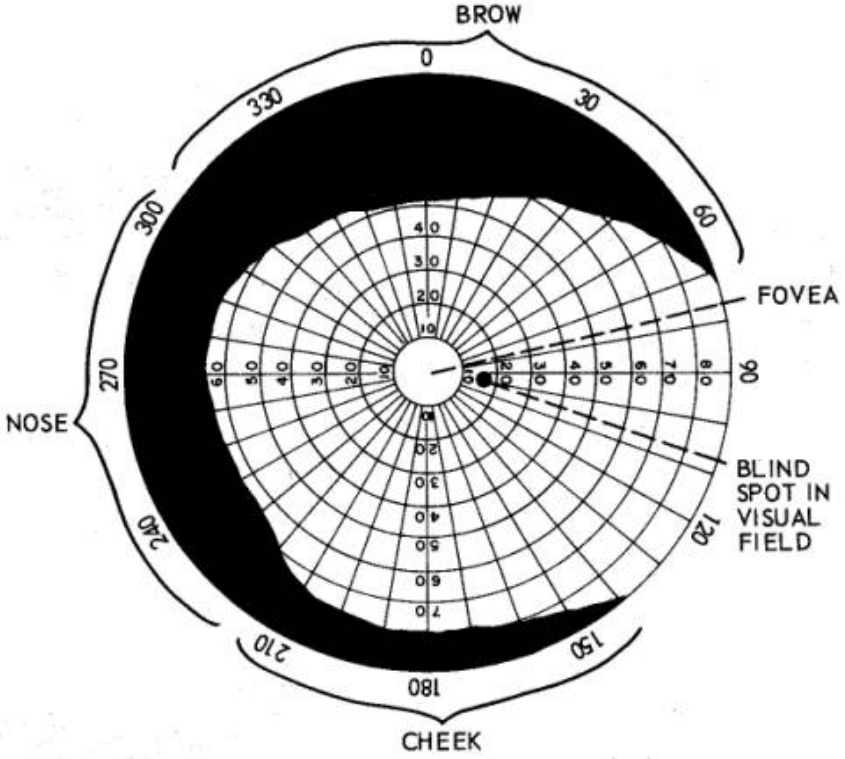
An 'average eye' likes to have things 25 cm away, or farther, for comfortable vision.

Young children can accommodate down to about 7 cm.

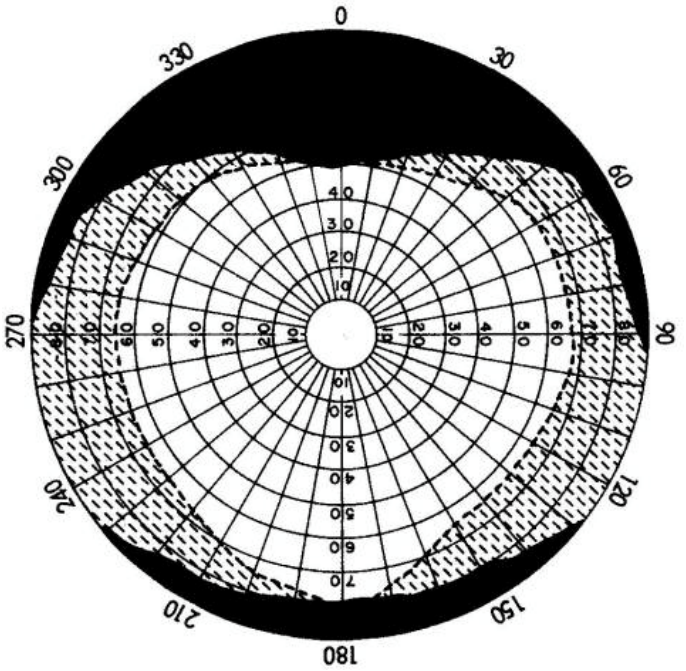


Field of View

Monocular visual field



Binocular visual field



Horizontal field of view: ~145° per eye
Vertical field of view: ~135°

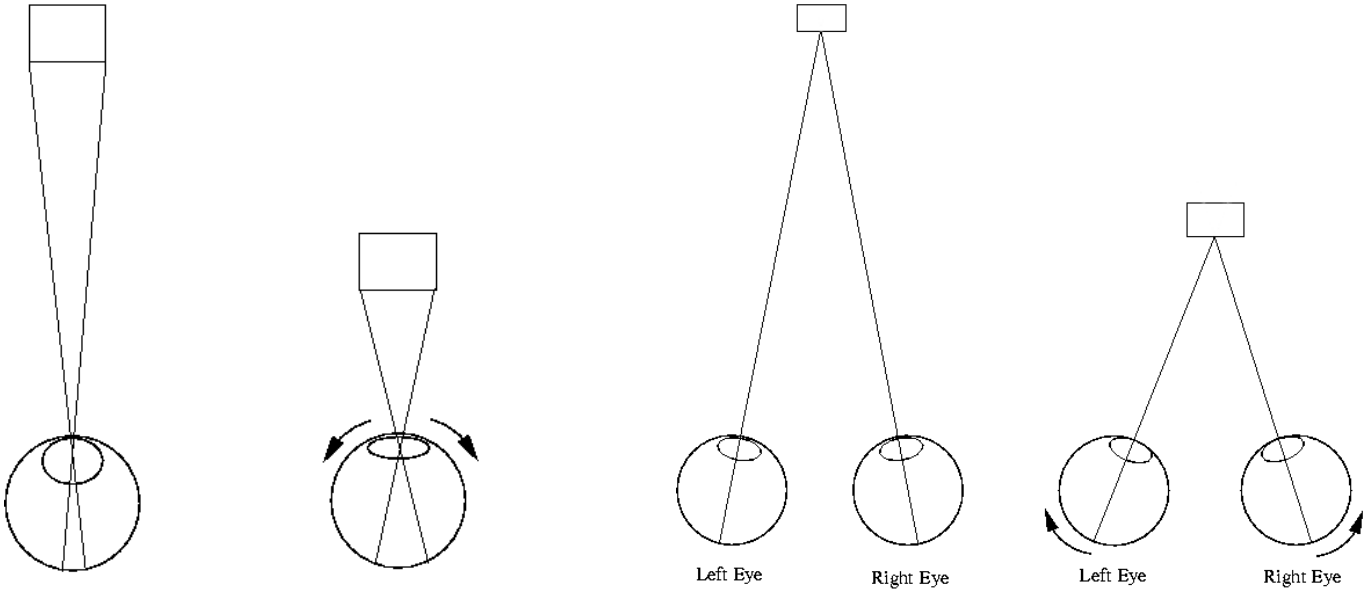
Ruch & Fulton, 1960

Stereo Vision

Convergence

Rotation of viewer's eyes so images can be fused together at varying distances

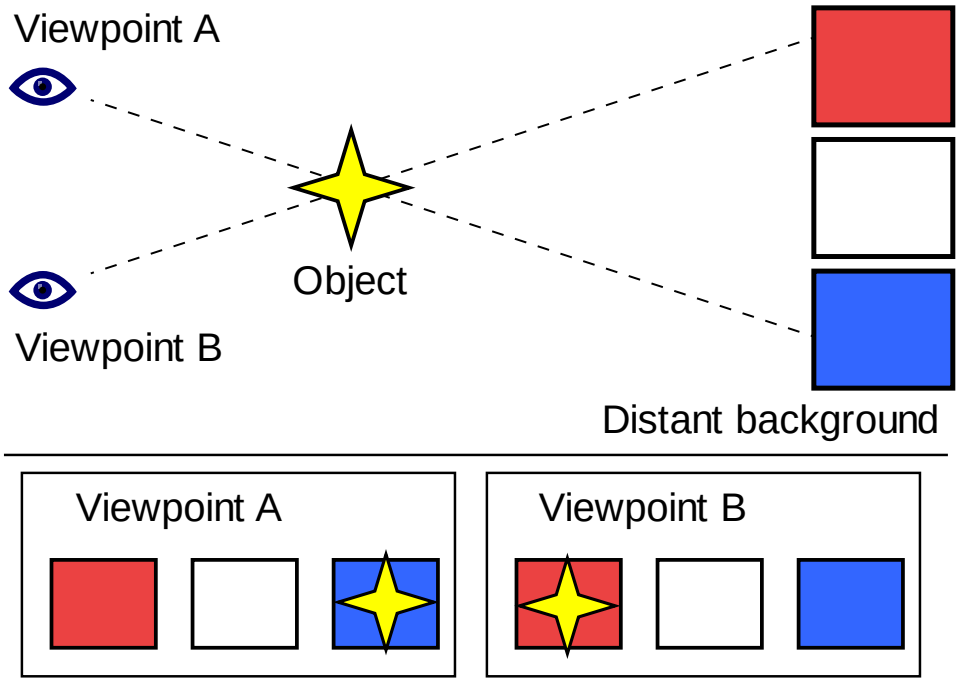
Do not confuse with accommodation!



Binocular Disparity and Stereopsis

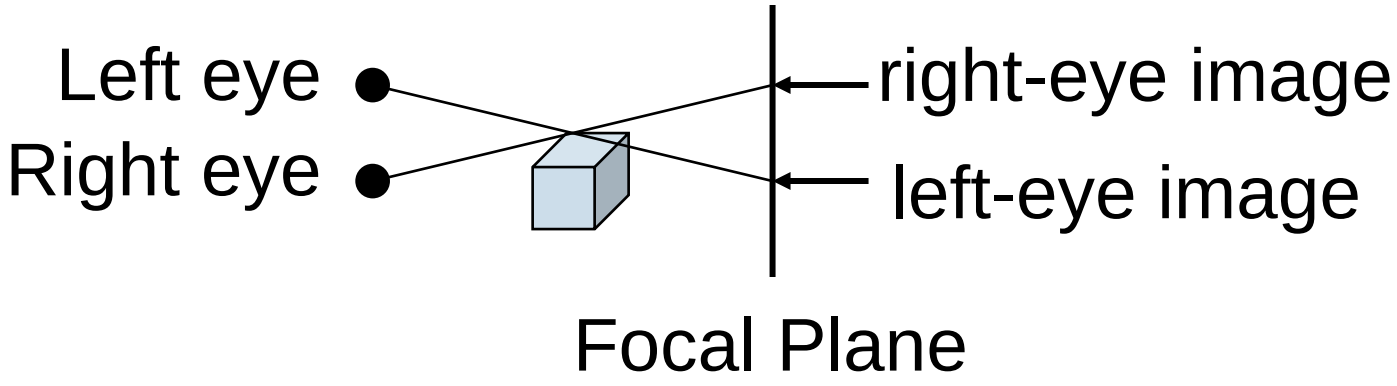
Each eye gets a slightly different image.

Only effective within a few feet from viewer.



Accommodation-Convergence Mismatch

The vast majority of current VR systems confuse the brain with contradicting oculomotor cues.
The accommodation-convergence mismatch comes from the fact that most VR displays have a fixed focal distance, but objects can be rendered to appear at any distance in the space due to their convergence cues.
Example: when you watch a 3D movie in the theater, your eyes' lenses constantly focus on the screen, the lens muscles' contraction doesn't change throughout the entire movie. However, as objects appear to be closer than the screen, your eyeballs converge at the object which appears at a different distance than what your lenses focus on.



Definitions

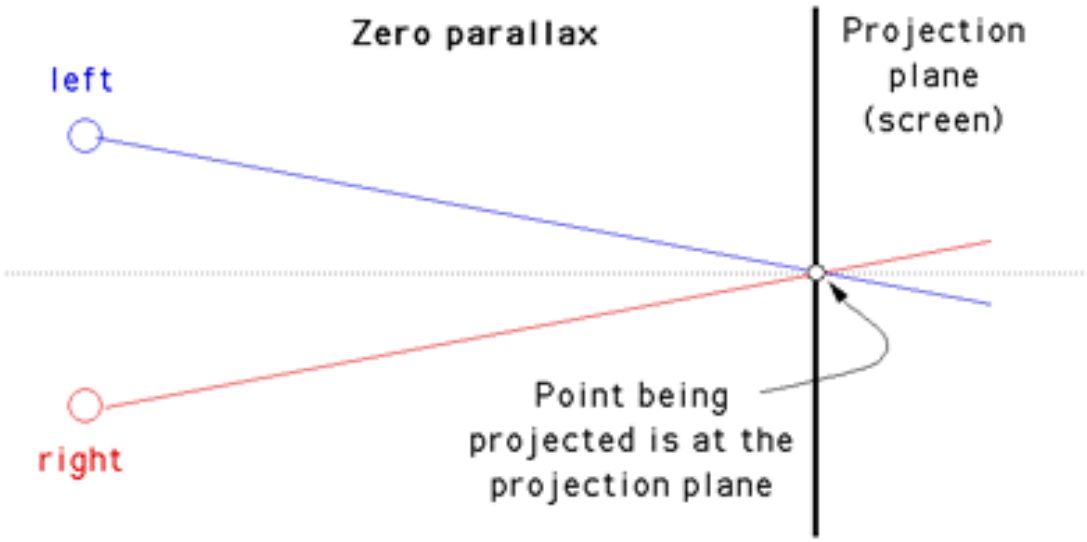
Focal distance: distance from the eye at which objects are "in focus“ - they look sharp rather than blurry.

Focal length: describes the zoom factor of a camera, the field of view (FOV) - it has nothing to do with accommodation or convergence.

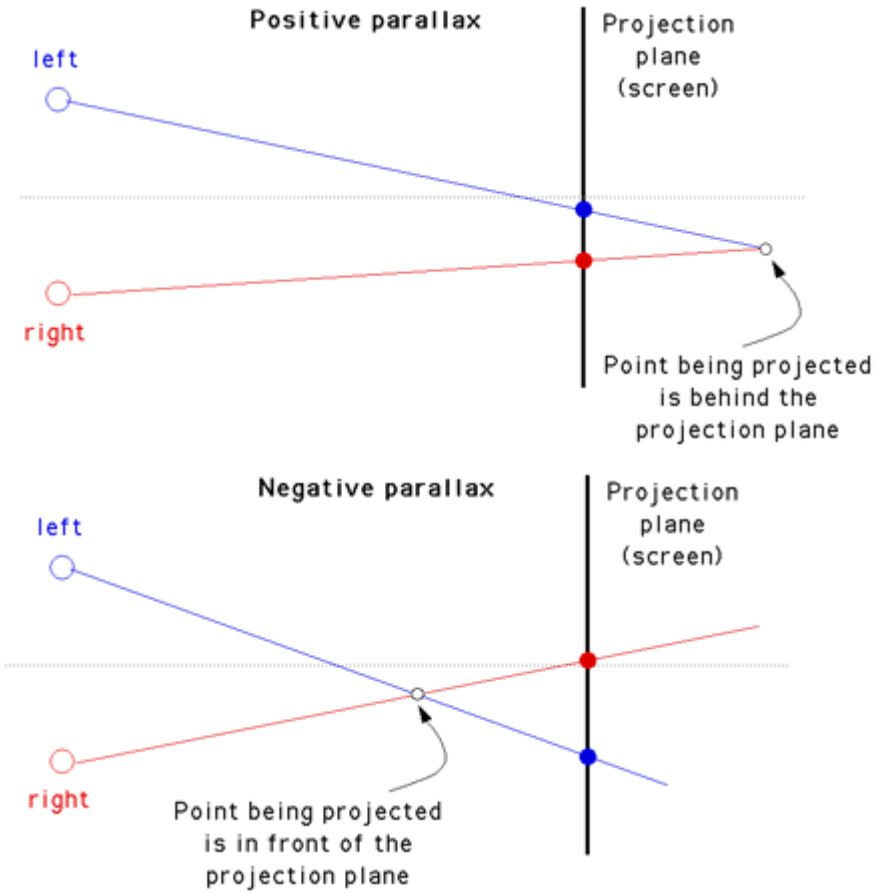
Convergence: the angle at which the eyeballs are pointed towards each other. For objects at infinity, this angle is near-zero. It grows the closer the object the person looks at is to their eyes.

Zero Parallax

Standard case for monoscopic displays



Stereo Parallax



Eye Separation

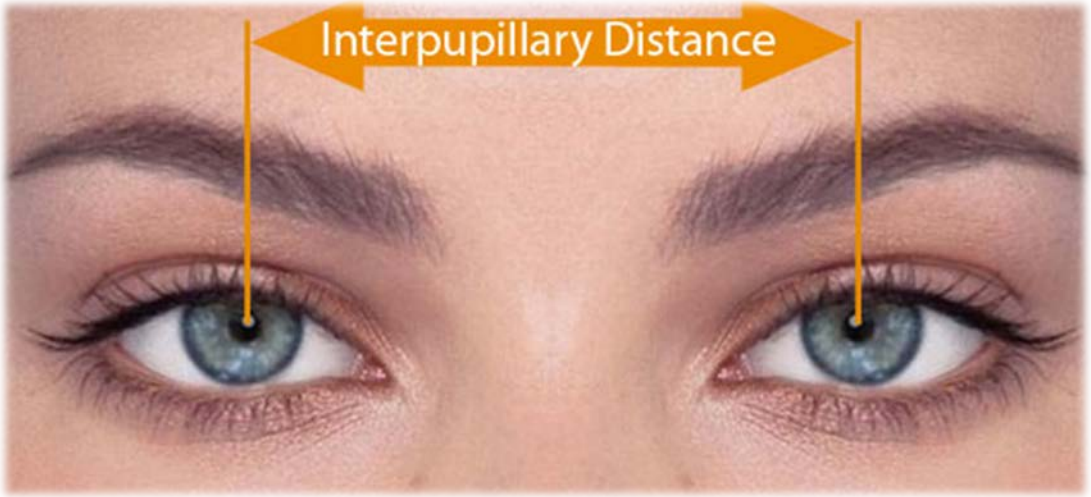
a.k.a. Eye Distance

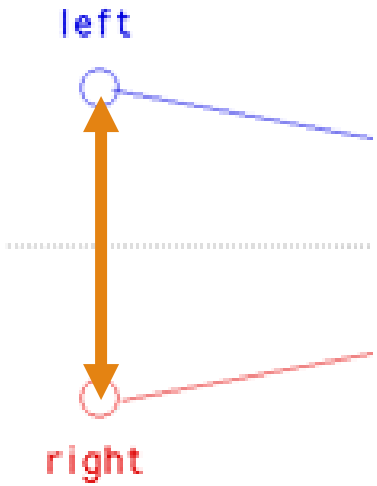
a.k.a. IOD = Interocular Distance

a.k.a. IPD = Interpupillary Distance

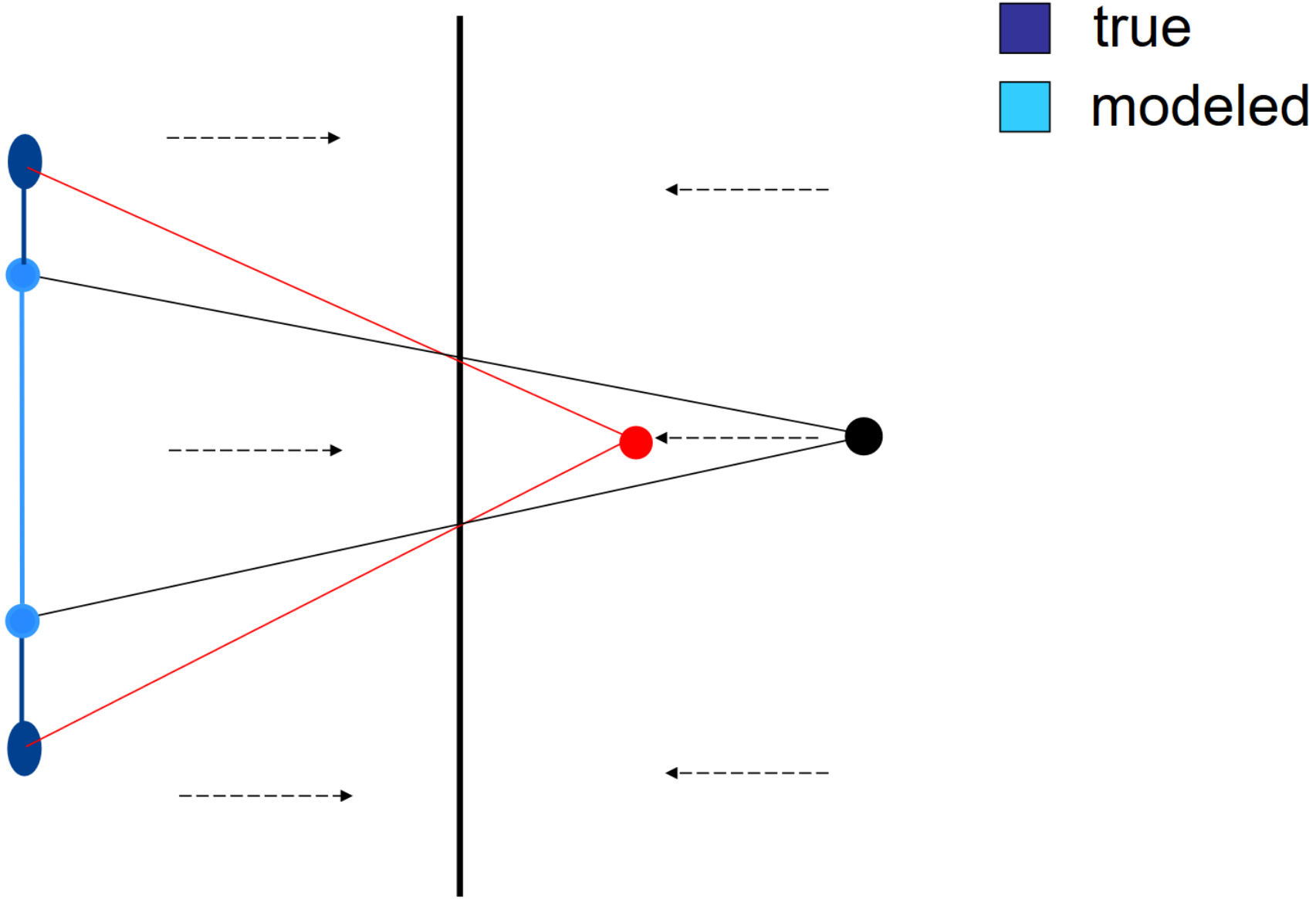
Averages:

- 62mm (2.44in) for women
- 64mm (2.52in) for men

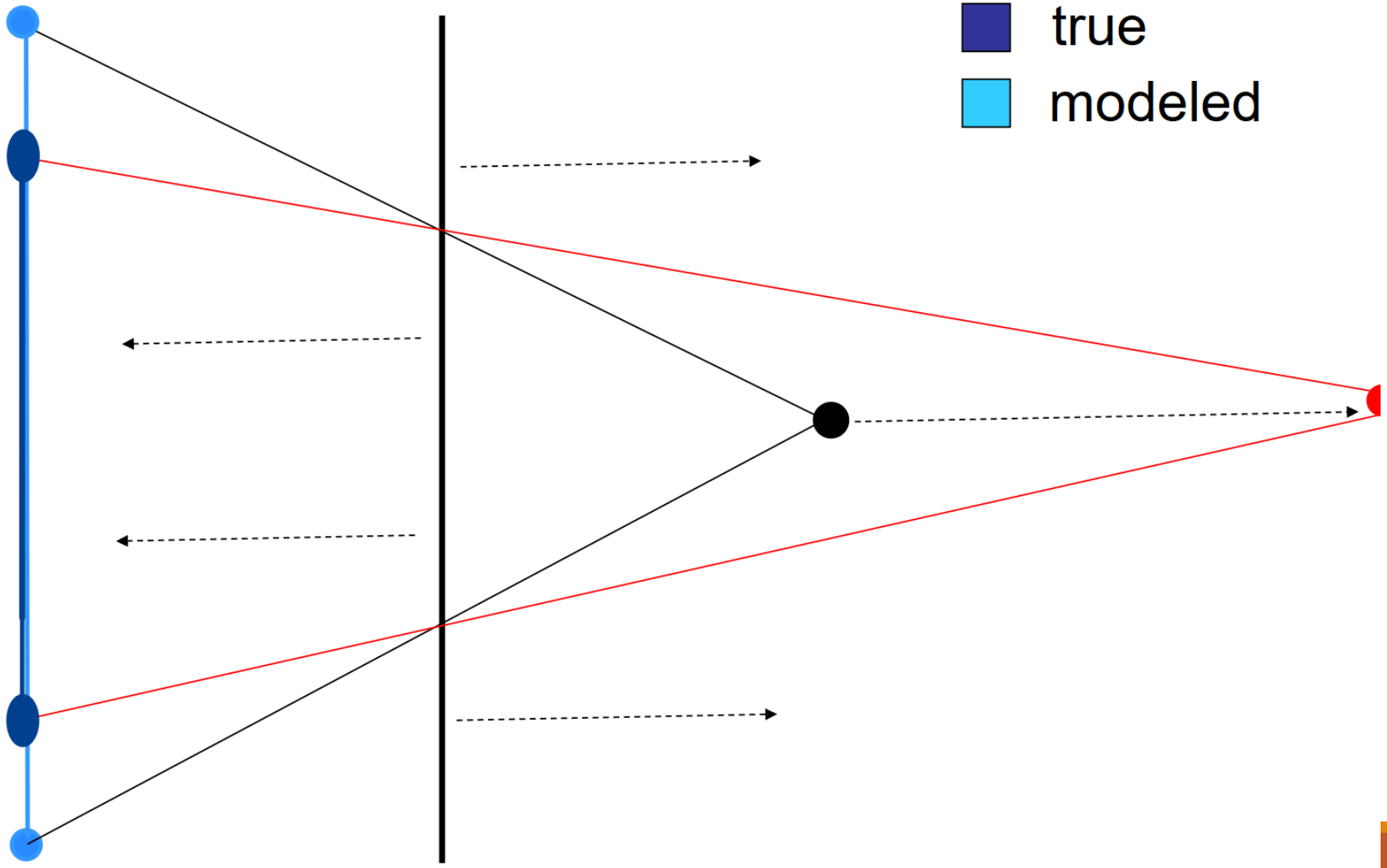




Viewer's IOD greater than average: compression



Viewer's IOD less than average: expansion



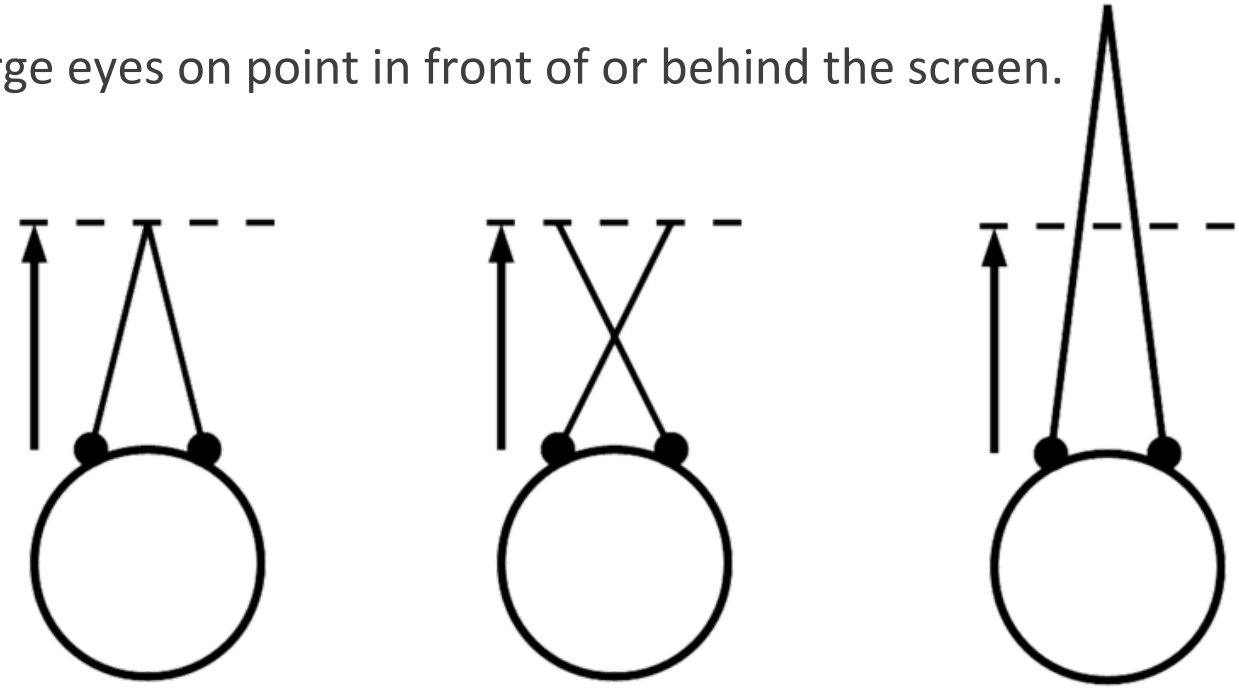
Reading: Autostereo Displays

http://ivl.calit2.net/wiki/index.php/Reading1S22

Single Image Stereogram (SIS)

No glasses required

Converge eyes on point in front of or behind the screen.



Aligned vergence and accommodation (normal viewing)

Cross-eyed vergence.
Arrow: accommodation

Wall-eyed convergence

SIRDS:
Single Image Random Dot Stereogram

A SIRDS encodes a 3D scene into an image in such a way that both eyes look at slightly distorted copies of the same (noisy) pattern.

The distortion of these copies is specifically crafted to encode the depth of each pixel in a rendered virtual 3D scene.

SIRDS use random dots instead of regular patterns to hide artefacts that could distract the viewer from the illusion.