CSE 190: Virtual Reality Technologies

LECTURE #3: DEPTH PERCEPTION

Announcements

Project 1 due next Friday April 19

- Team project (teams of two)

Monday: discussion of project 1 at 3pm in VR lab

Depth Cues – How Do We See 3D?

Monocular, static cues
- Relative size
- Occlusion
- Location in image
- Perspective foreshortening
- Shadows

Motion parallax

Occulomotor cues
- Accommodation
- Convergence

Binocular disparity and stereopsis

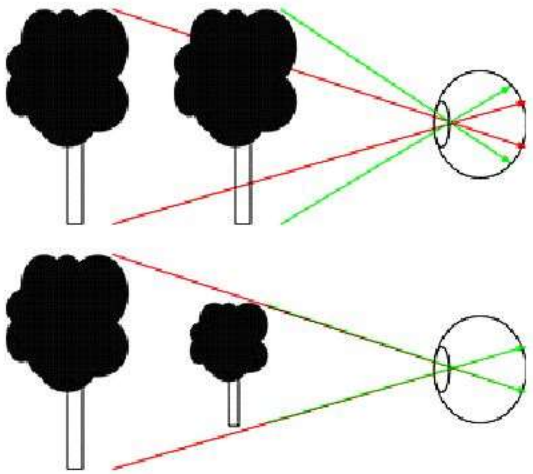
→ All of the above, combined, determine our perception of depth

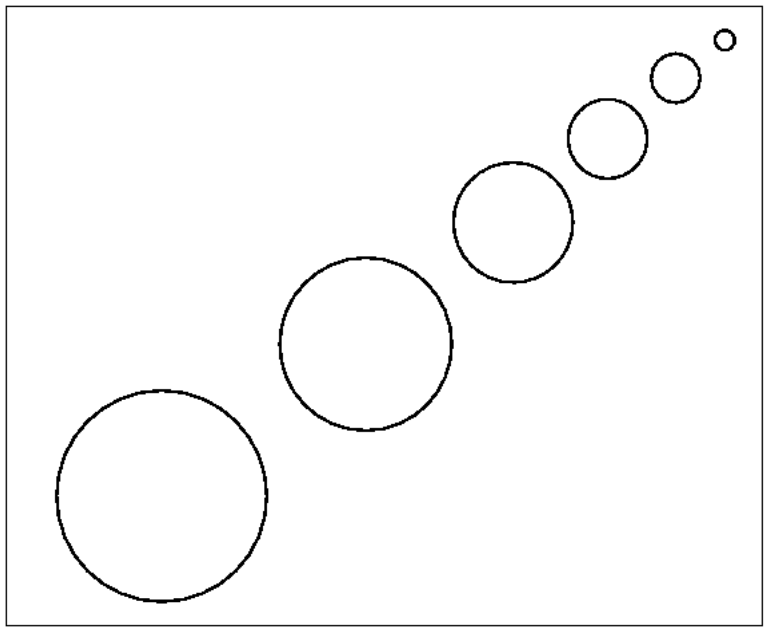
Monocular Depth Cues

Relative Size

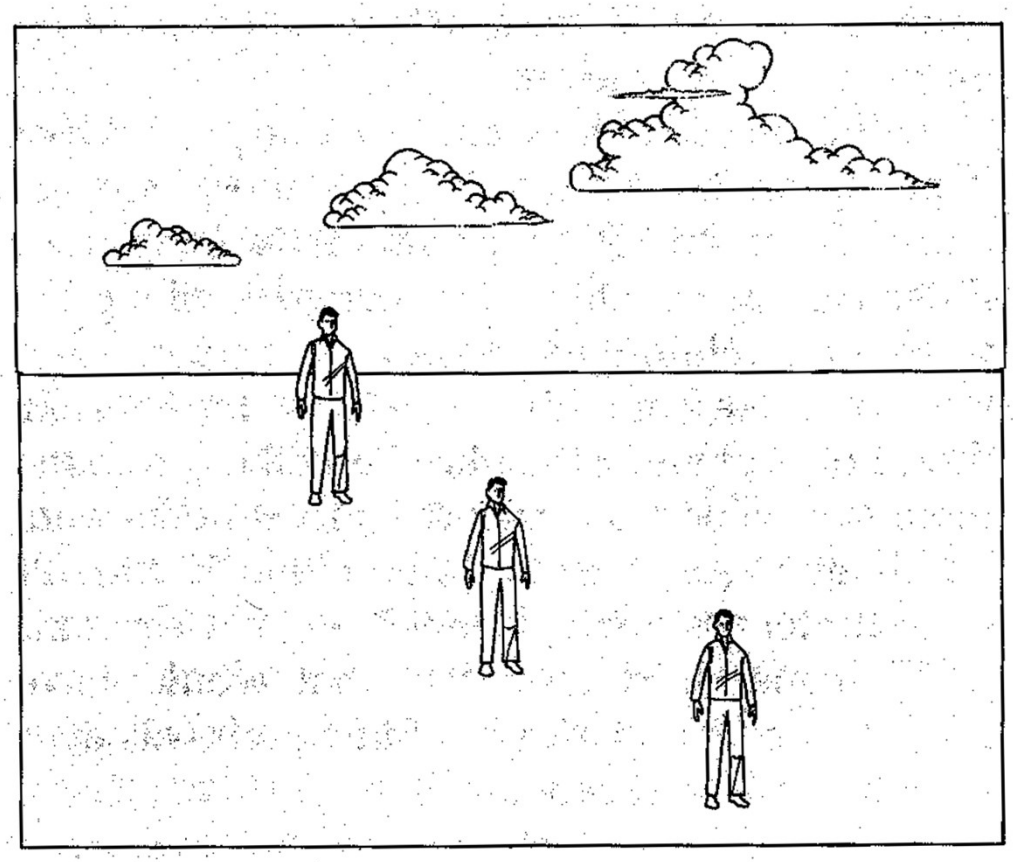
Monocular depth cues

Retinal projection depends on size and distance

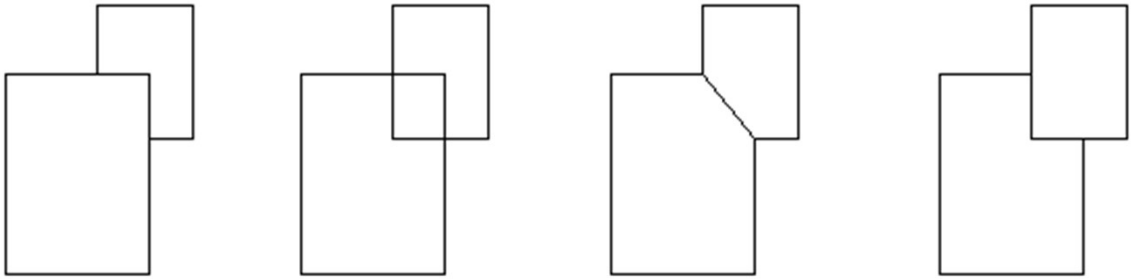




Height relative to horizon



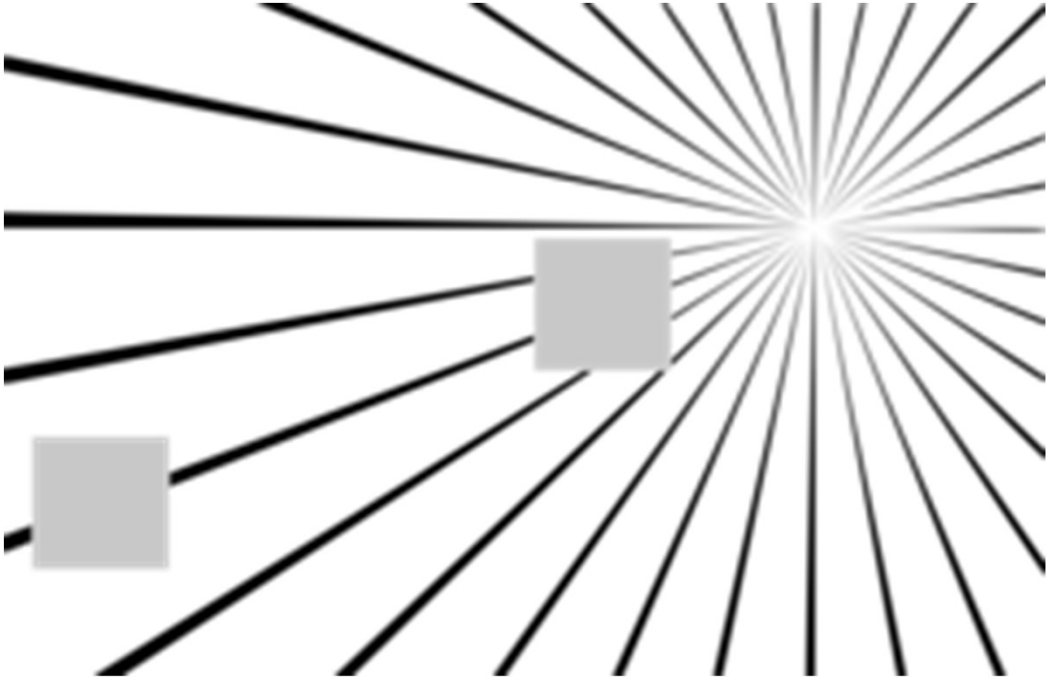
Occlusion



Depth perception based on overlapping. The object with more continuous border line is felt to lie closer. In figure (a) it is the larger rectangle and in figure (d) it is the smaller. In figures (b) and (c) no depth information can be obtained.

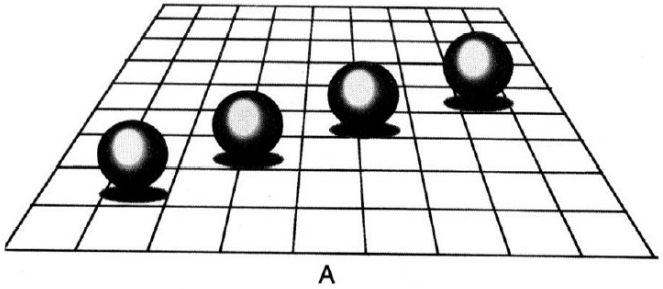
http://www.hitl.washington.edu/projects/knowledge_base/virtual-worlds/EVE/III.A.1.c.DepthCues.html

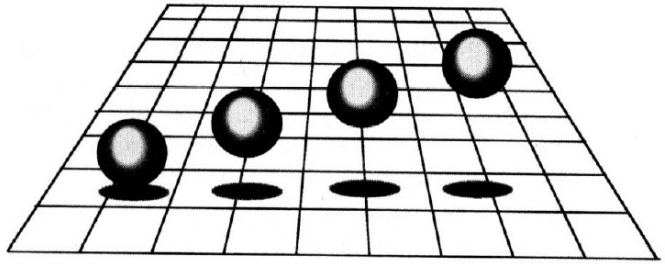
Linear Perspective

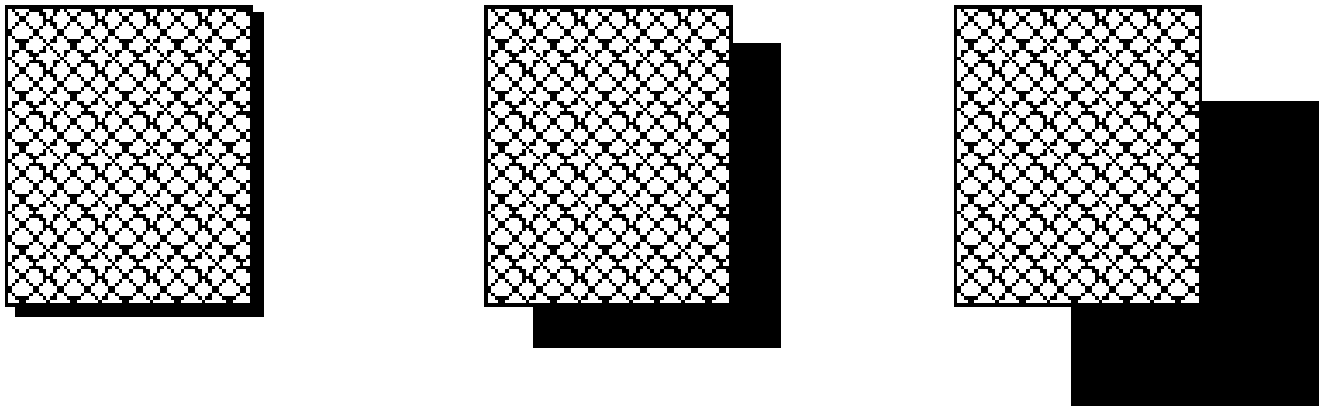


http://anthonysaba.wikispaces.com/Depth+Perception

Shadows



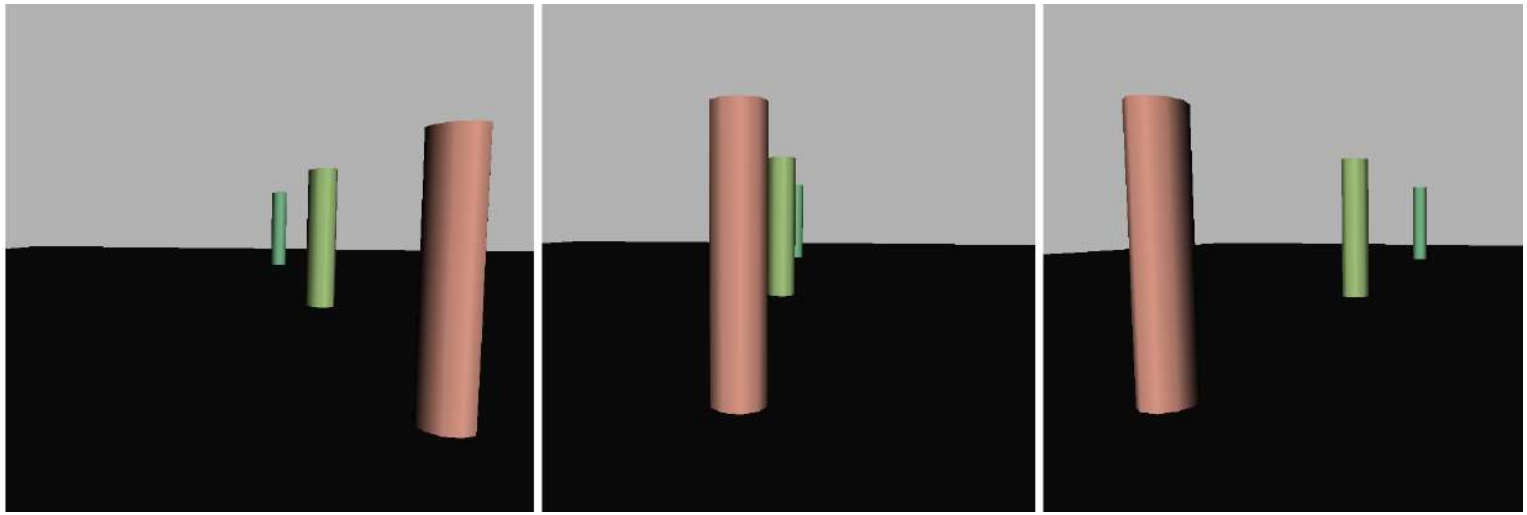




Motion Parallax

Moving viewer

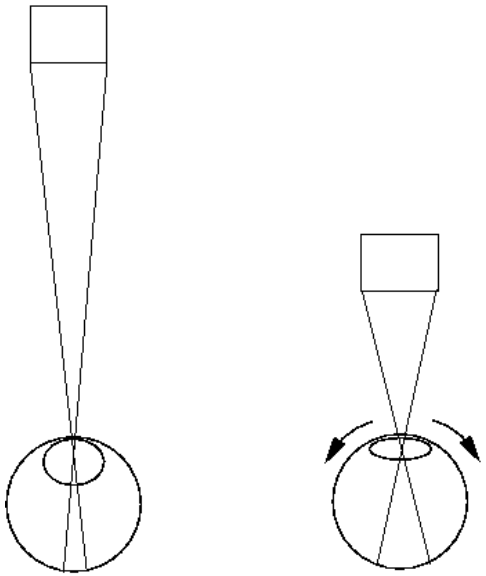
In image sequence below, viewer moves to the right



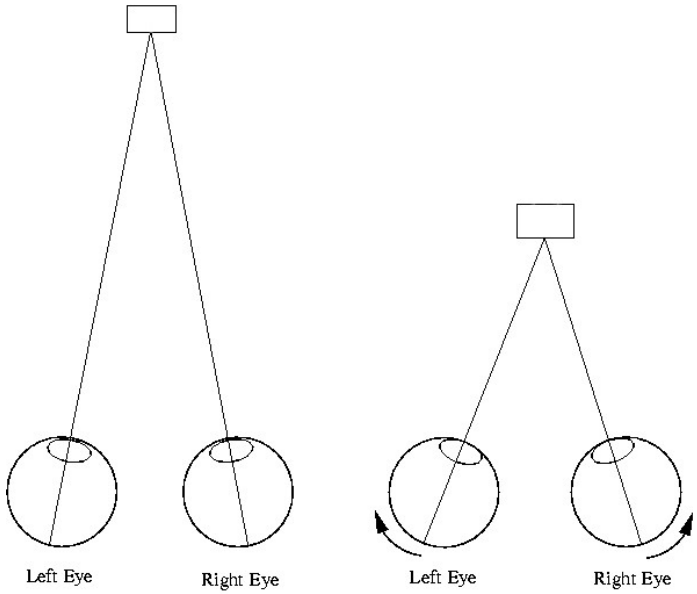
Accommodation

Physical stretching and relaxing of eye lens

Do not confuse with convergence!



Accomodation



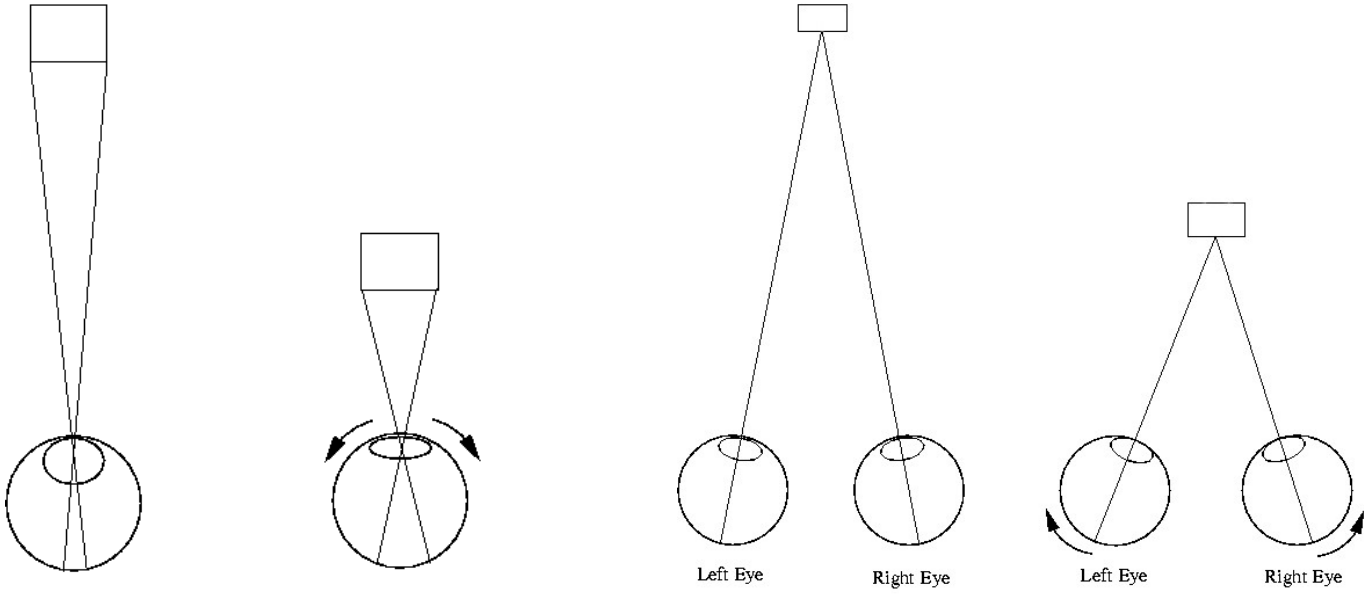
Convergence

Stereo Vision

Convergence

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

Do not confuse with accommodation!



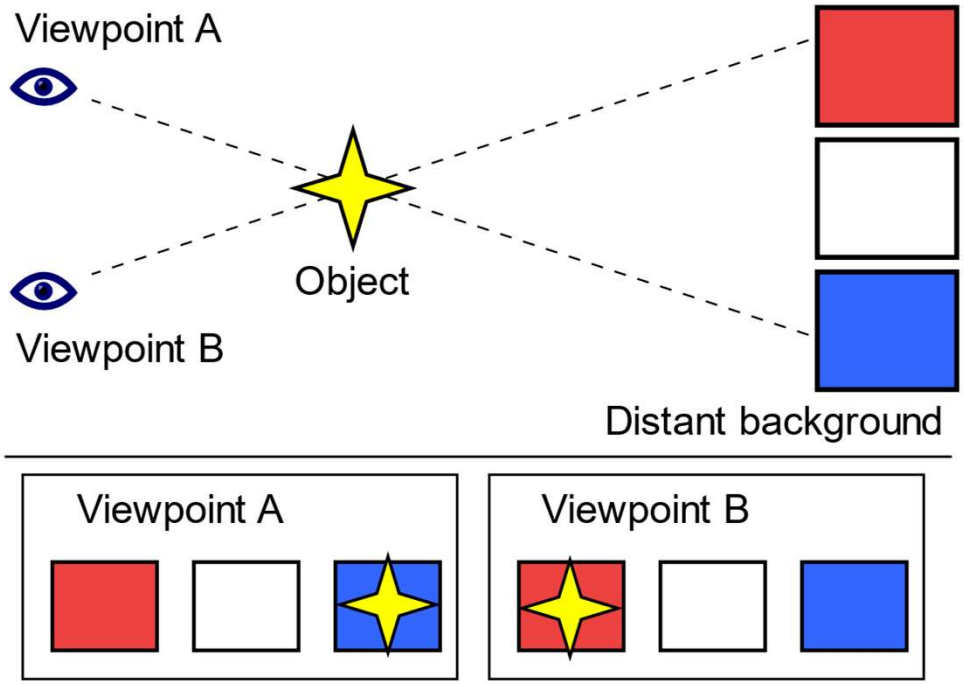
Accomodation

Convergence

Binocular Disparity and Stereopsis

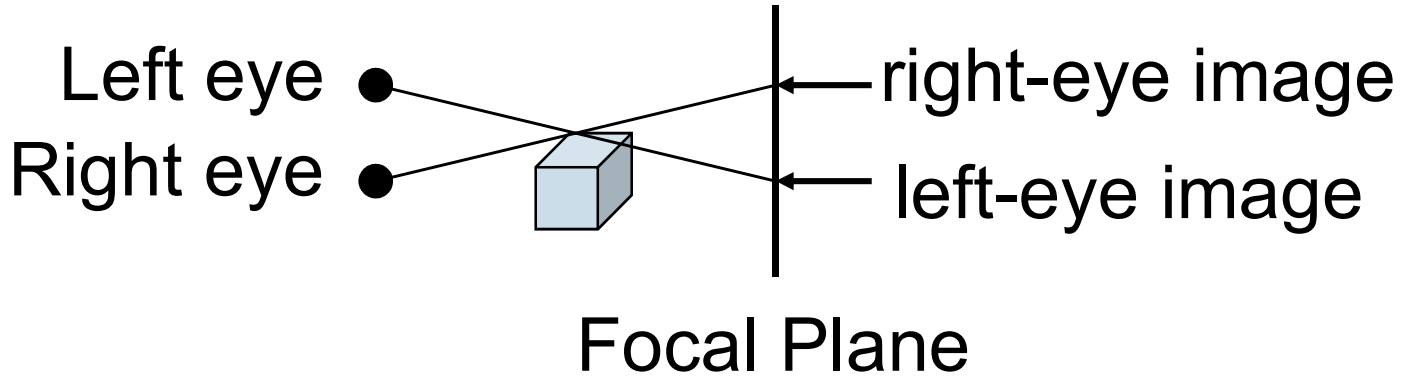
Each eye gets a slightly different image.

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

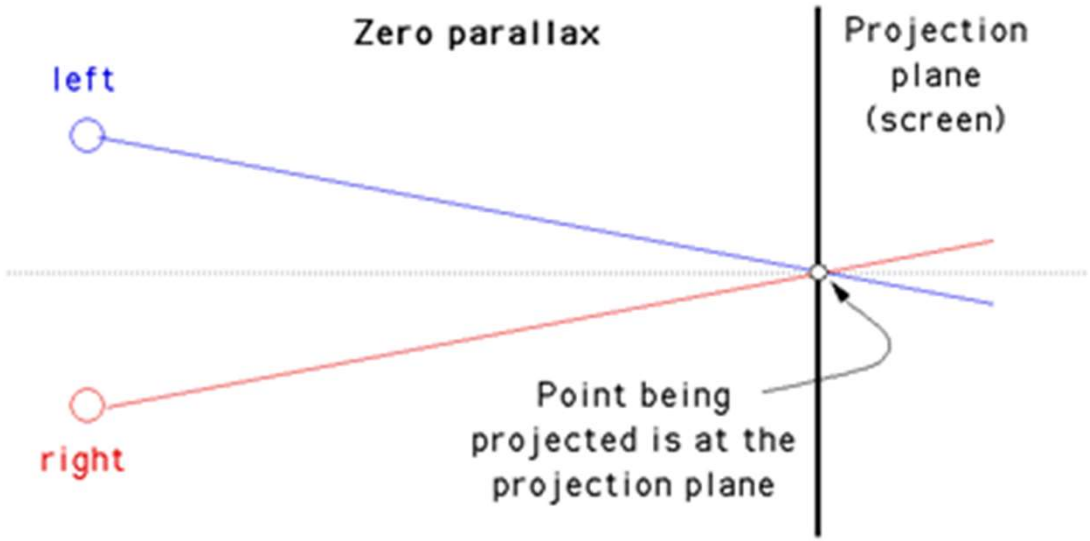
Focal distance: distance from the eye at which objects are "in focus“ - they look sharp rather than blurry.

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

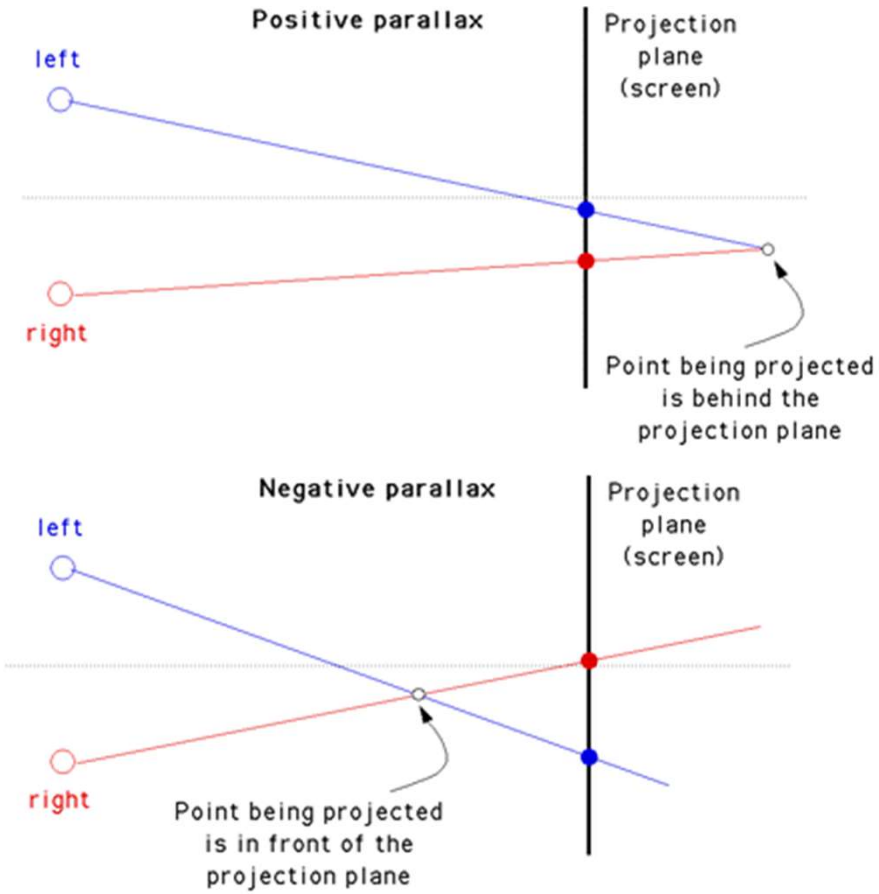
Convergence: the angle at which the eyeballs are pointed towards each other. For objects at infinity, this angle is near-zero. It grows the closer the object the person looks at is to their eyes.

Zero Parallax

Standard case for monoscopic displays



Stereo Parallax



Eye Separation

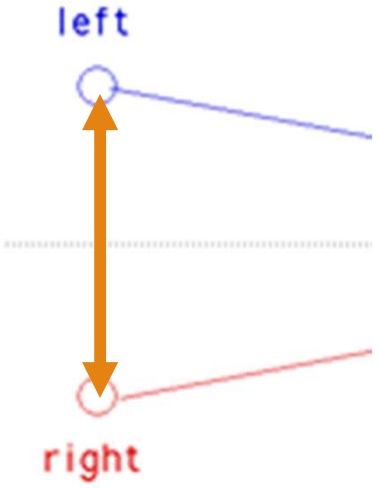
a.k.a. Eye Distance

a.k.a. IOD = Interocular Distance

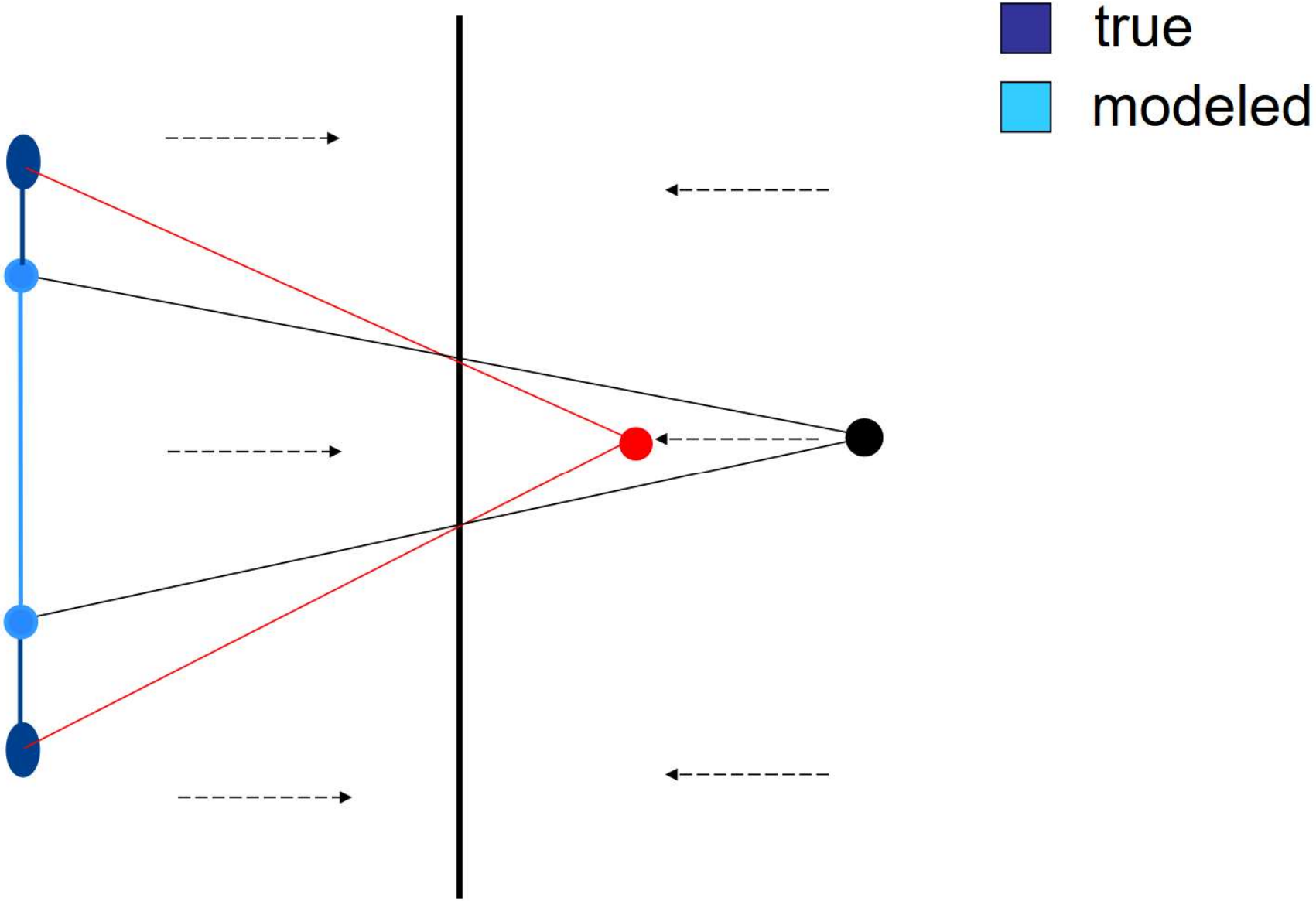
a.k.a. IPD = Interpupillary Distance

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