universidade de aveiro
theoria poiesis praxis

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Human Perception & VR Technology

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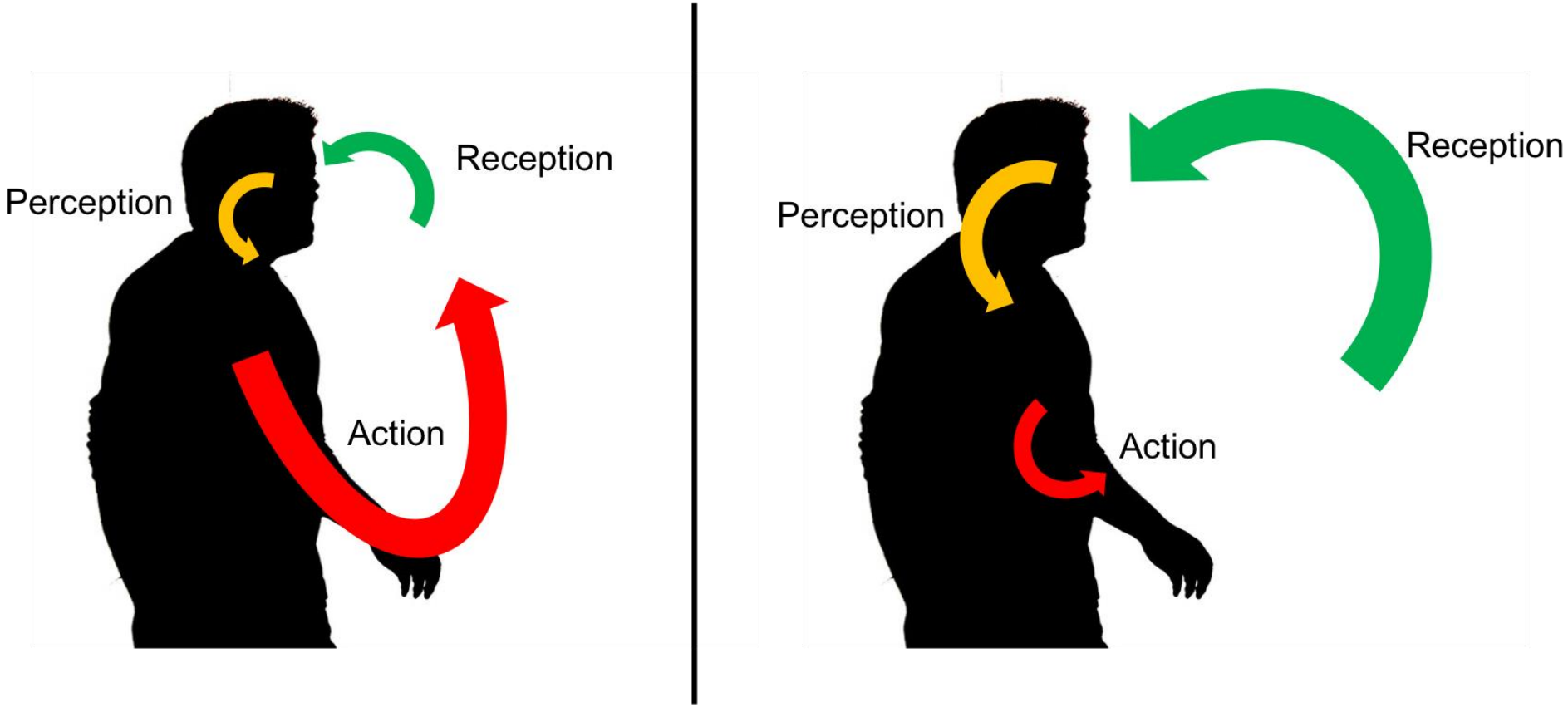
PORTUGAL 2030

Human Action Cycle

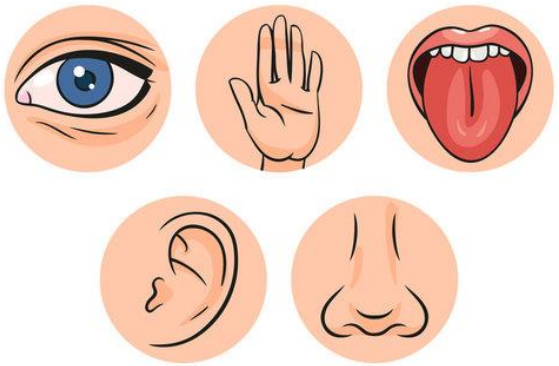


Perception

Percentage of neurons in brain devoted to each sense

- Sight – 30%
- Touch – 8%
- Hearing – 2%
- Smell - < 1%

Over 60% of brain involved with vision in some way



Other senses

Proprioception = sense of body position
- what is your body doing right now

Equilibrium = balance

Acceleration

Nociception = sense of pain

Temperature

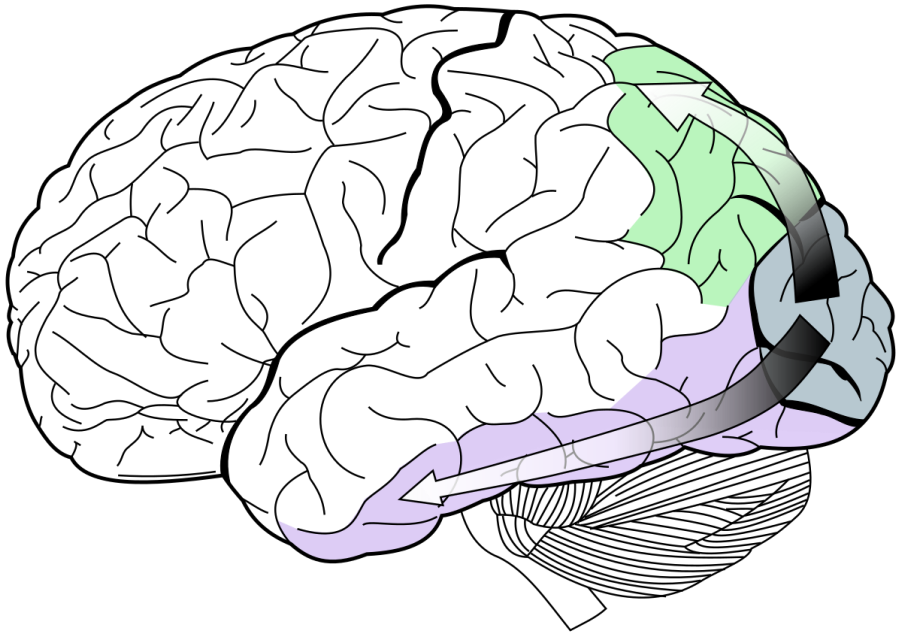
Satiety

Thirst

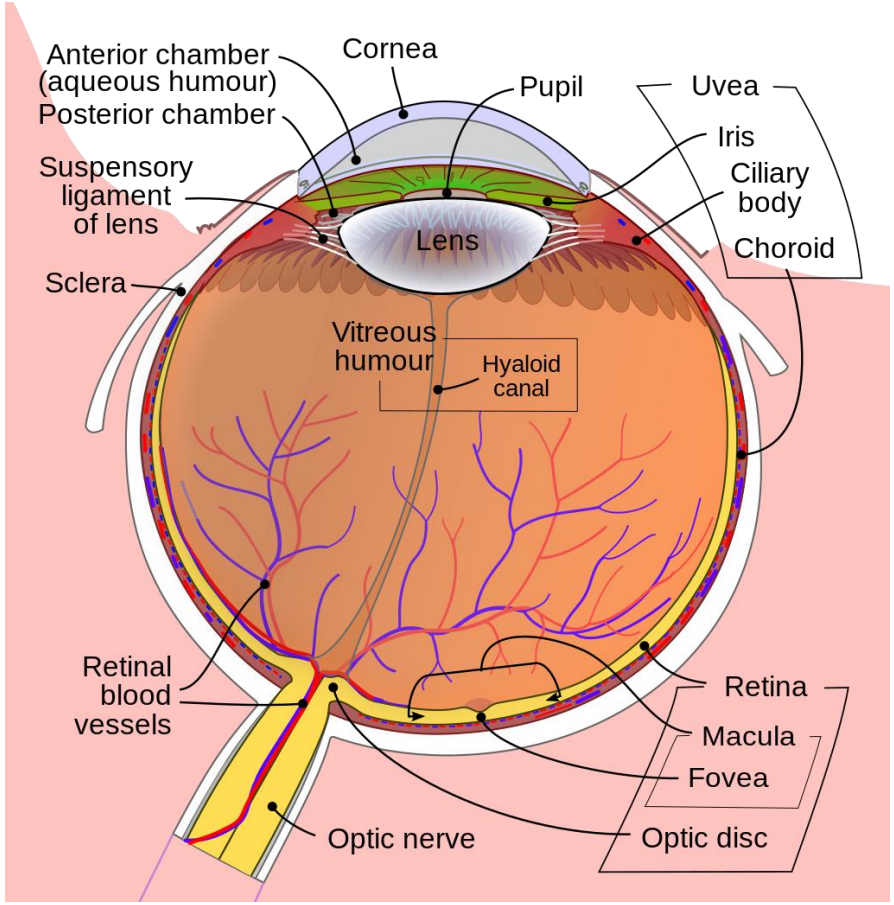
Micturition

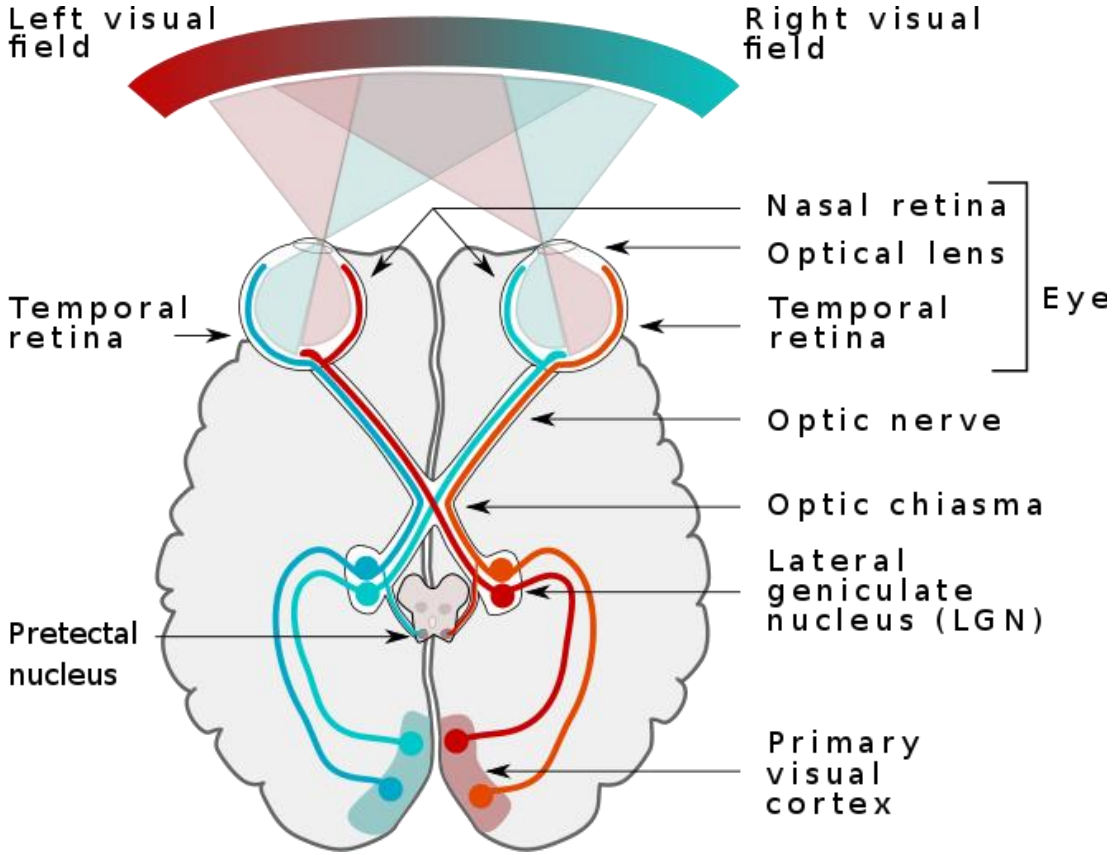
Amount of CO_2 and Na in blood

Human Visual System

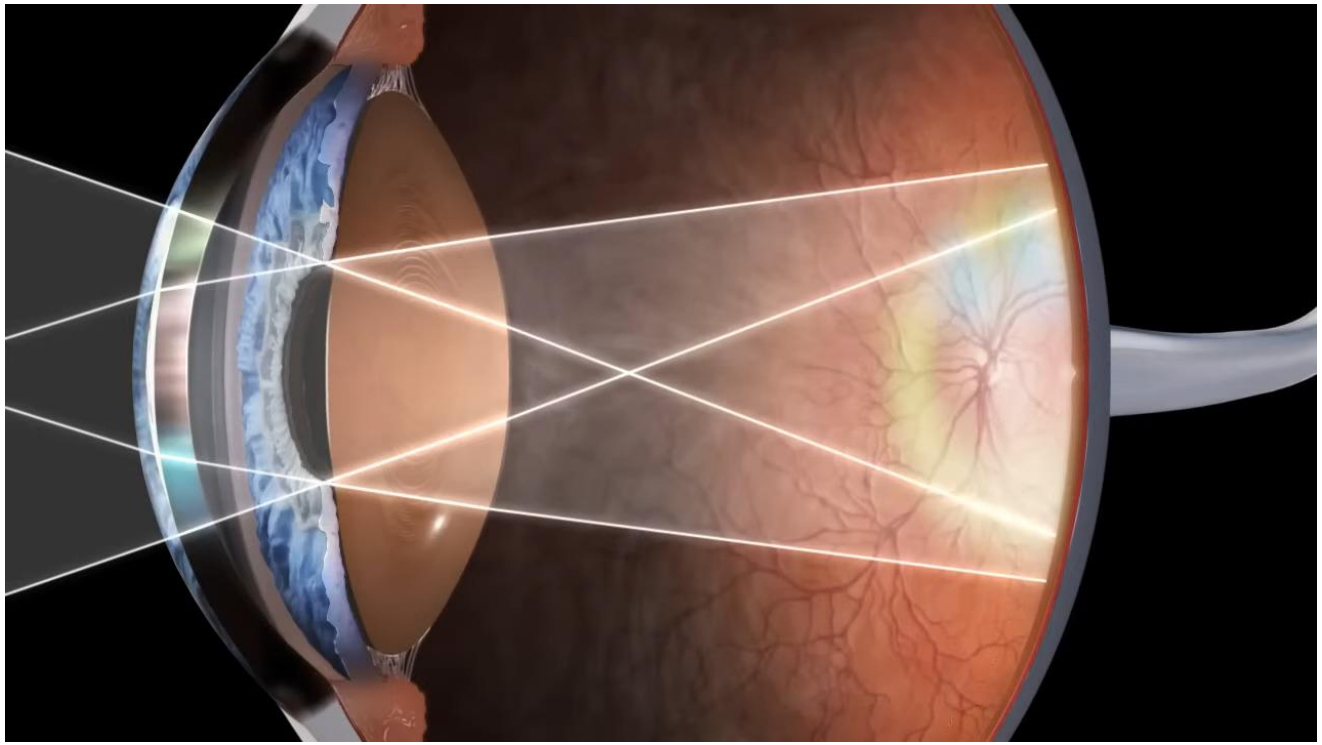


Human Visual System

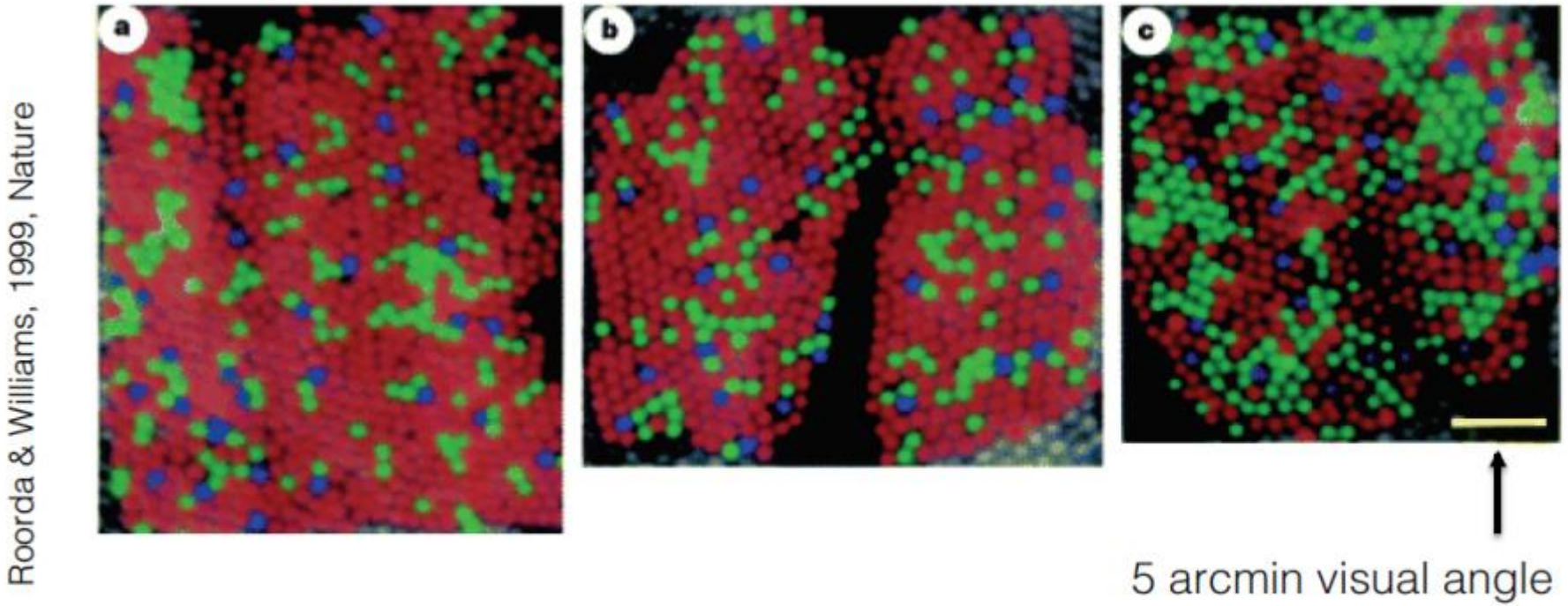




Human Visual System

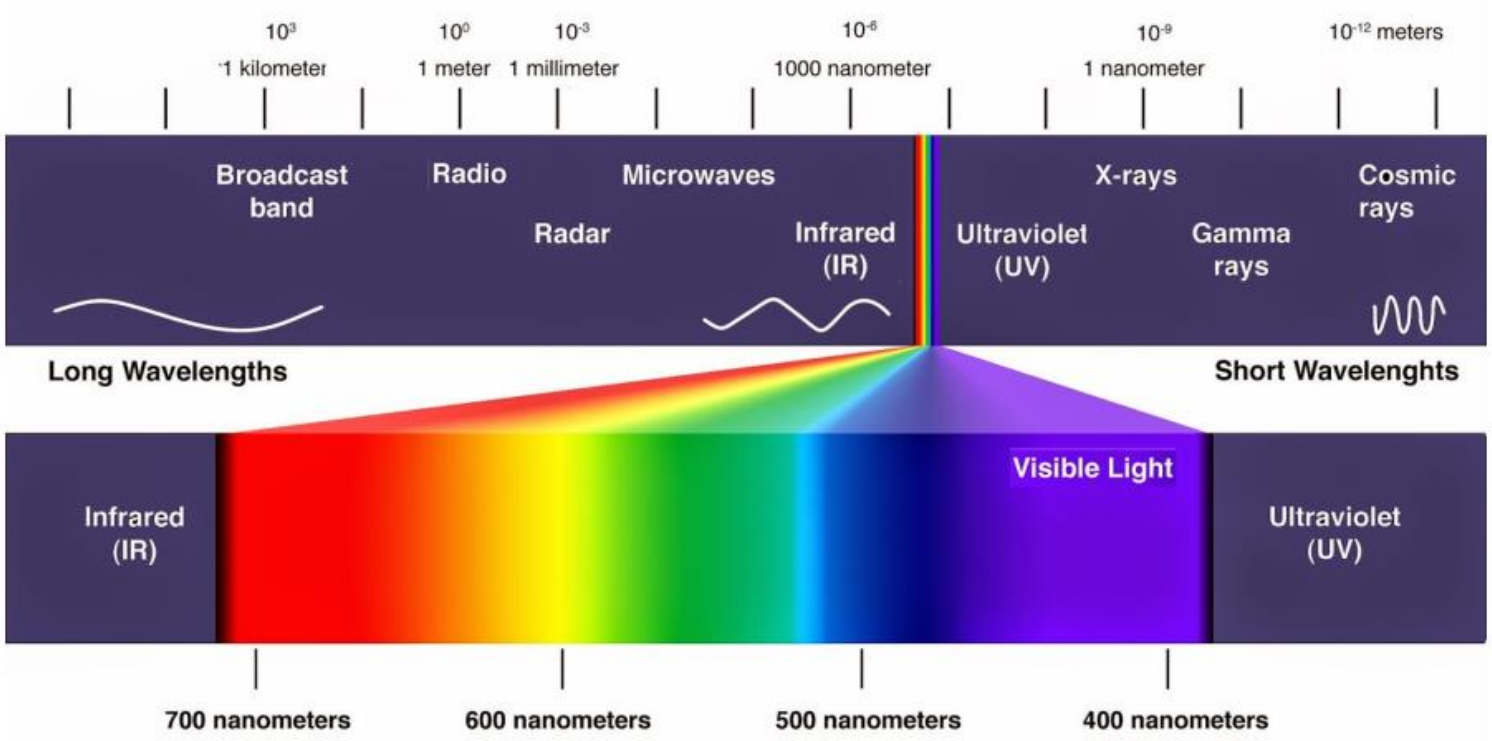


Color Perception

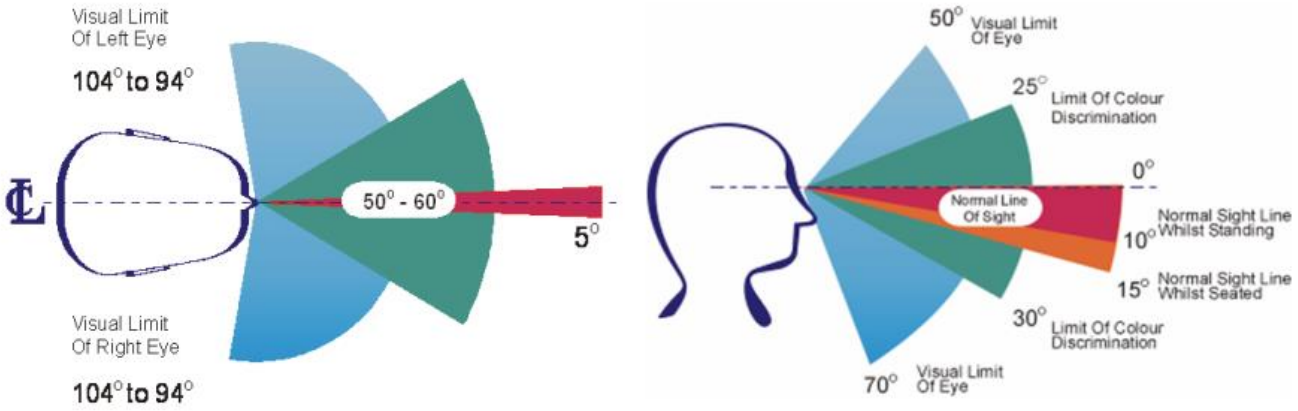


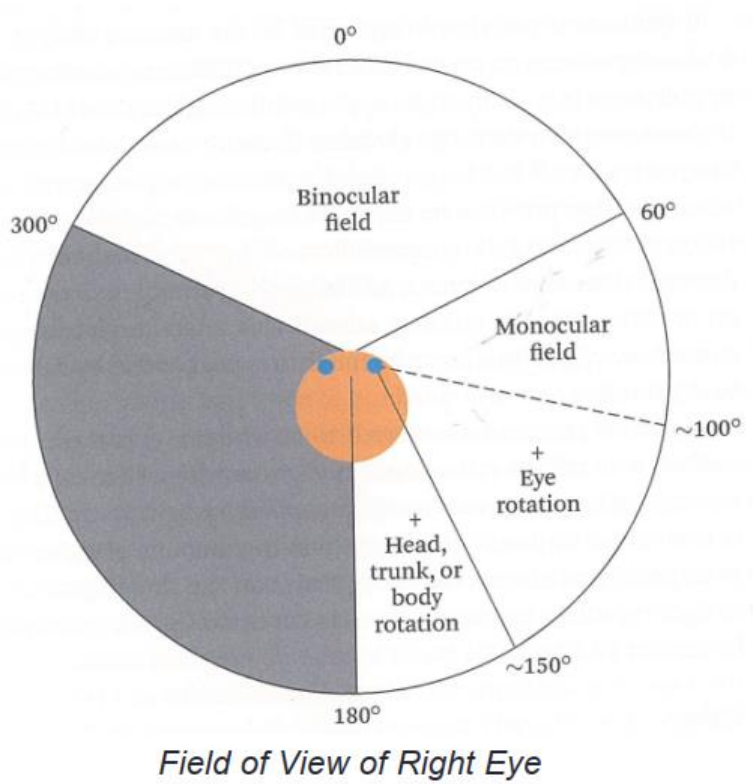
photoreceptors: 3 types of cones (color vision), rods (luminance only, night vision)

Color Perception



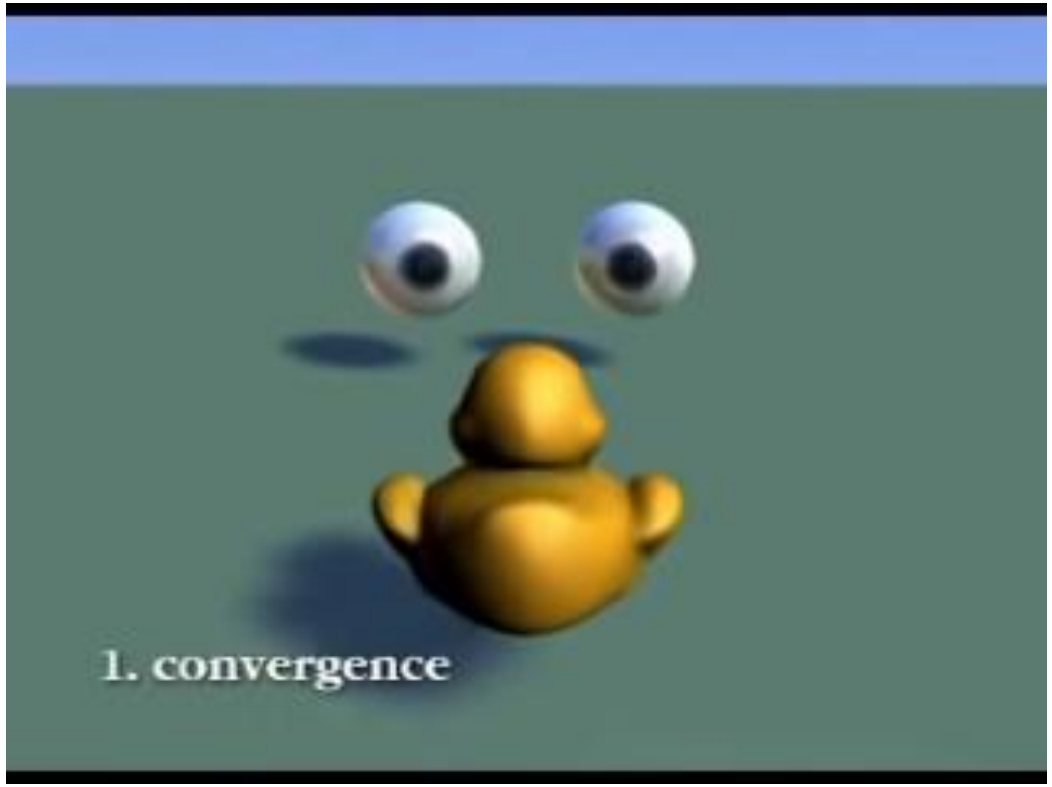
Field of View



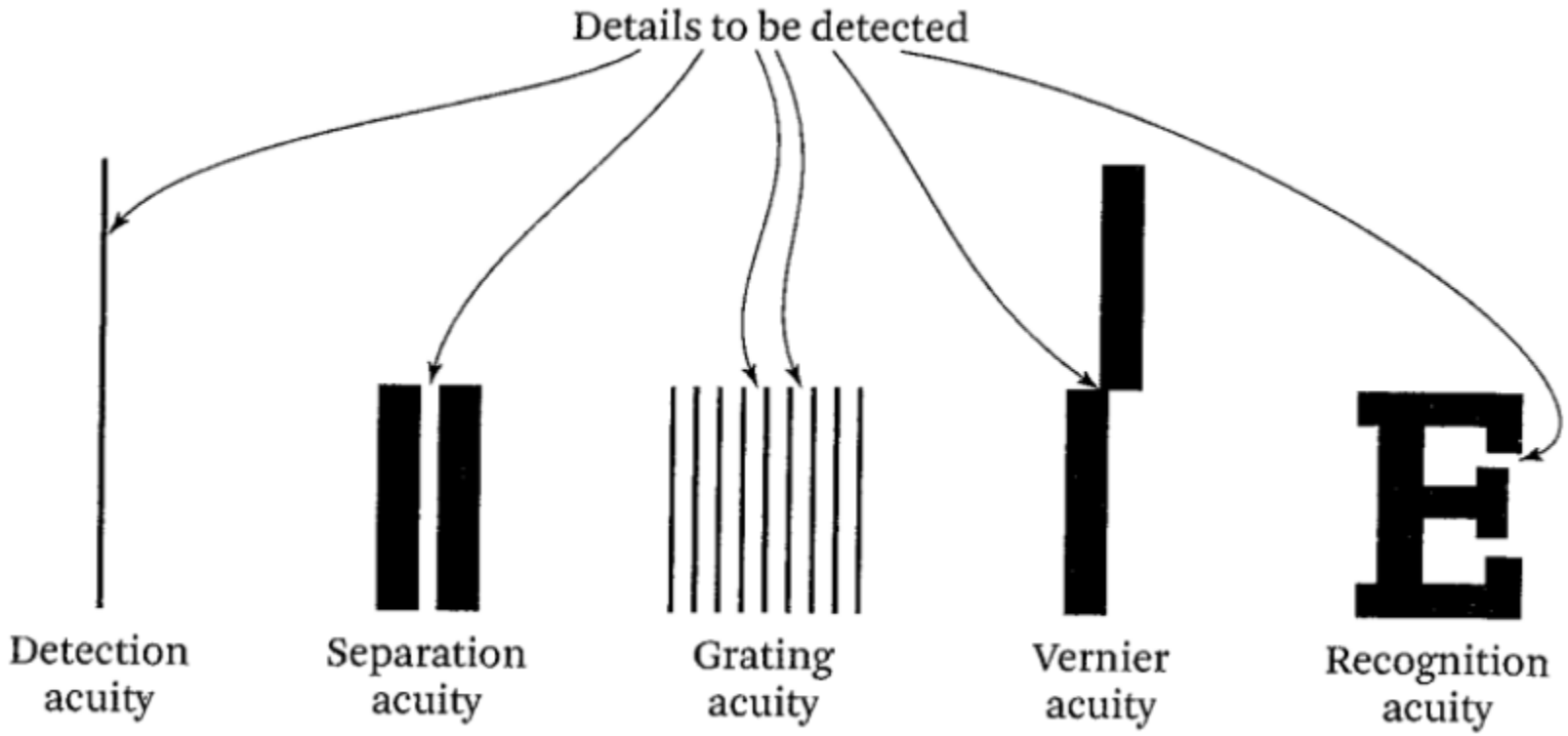


Field of View of Right Eye

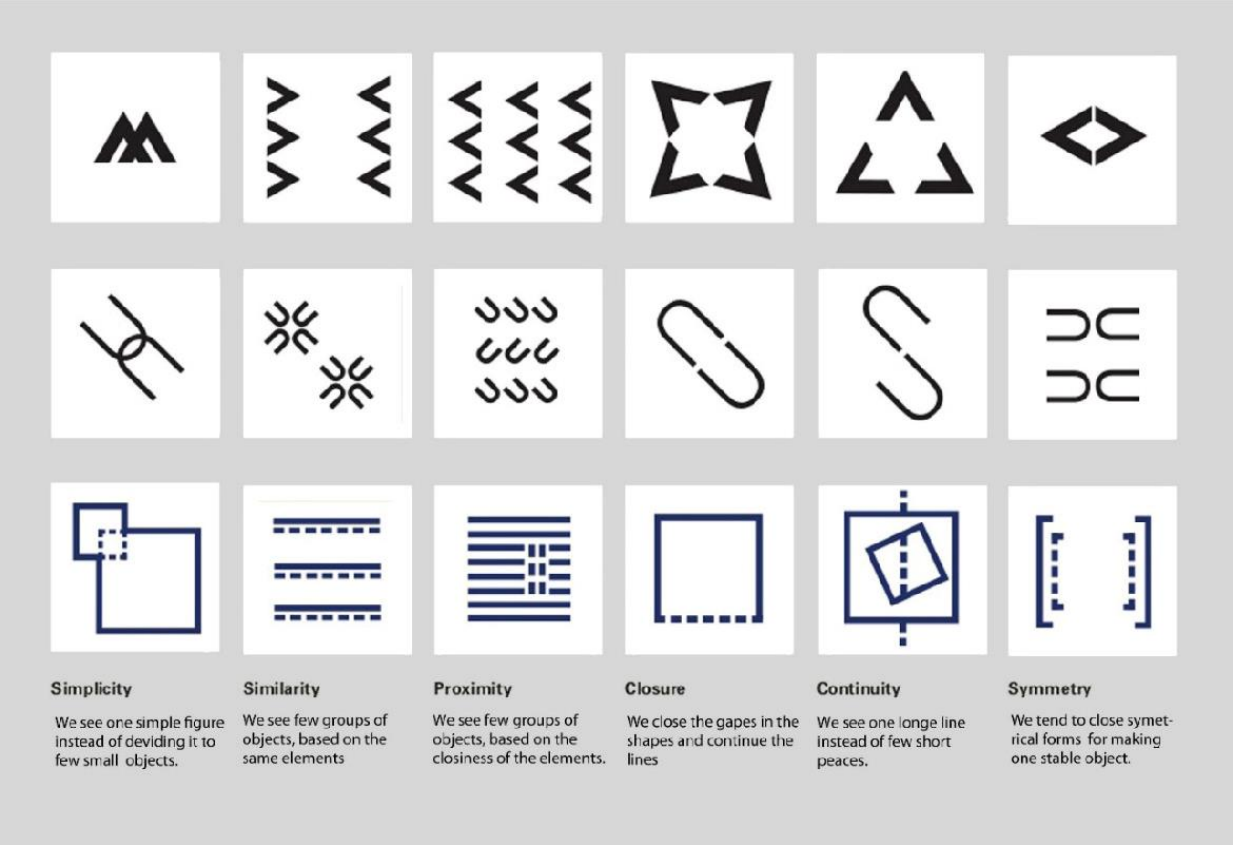
Vergence/Accommodation Demo



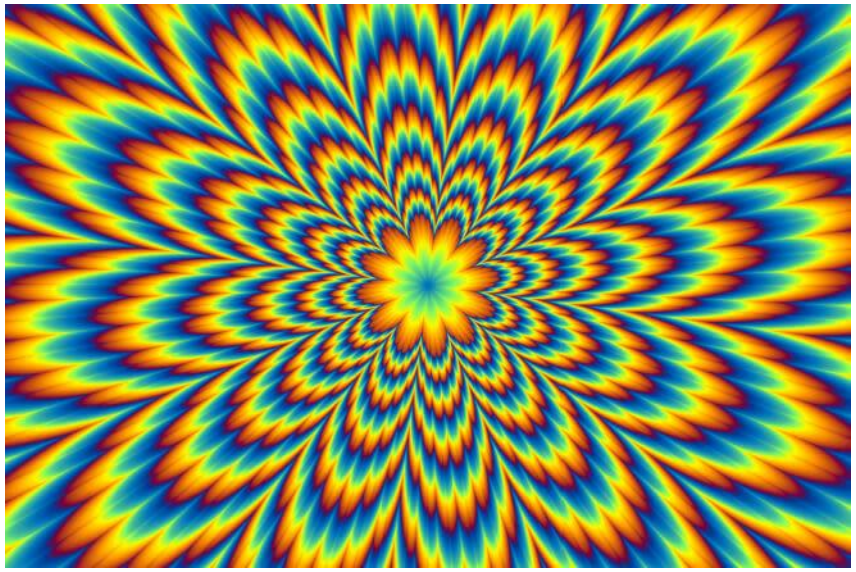
Visual Acuity

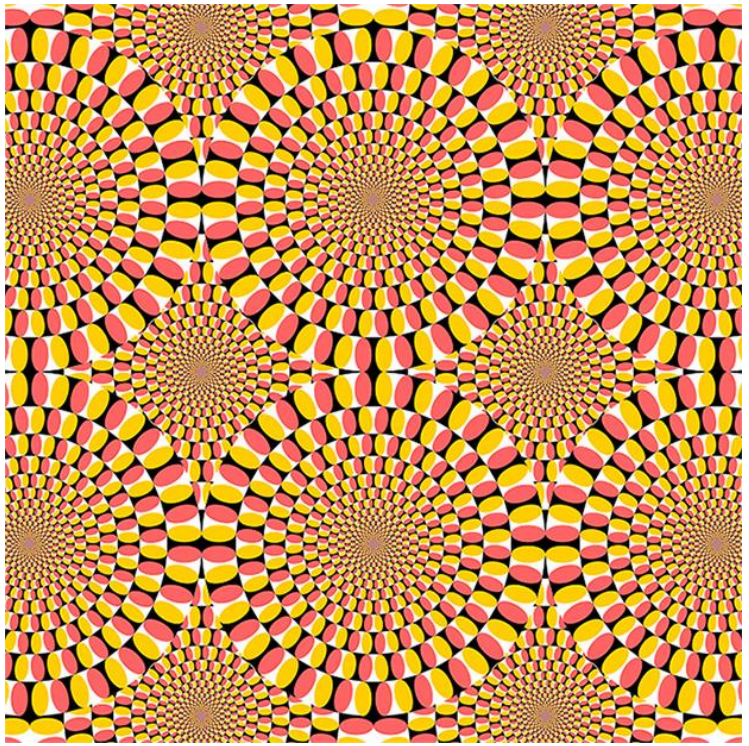


Gestalt principles

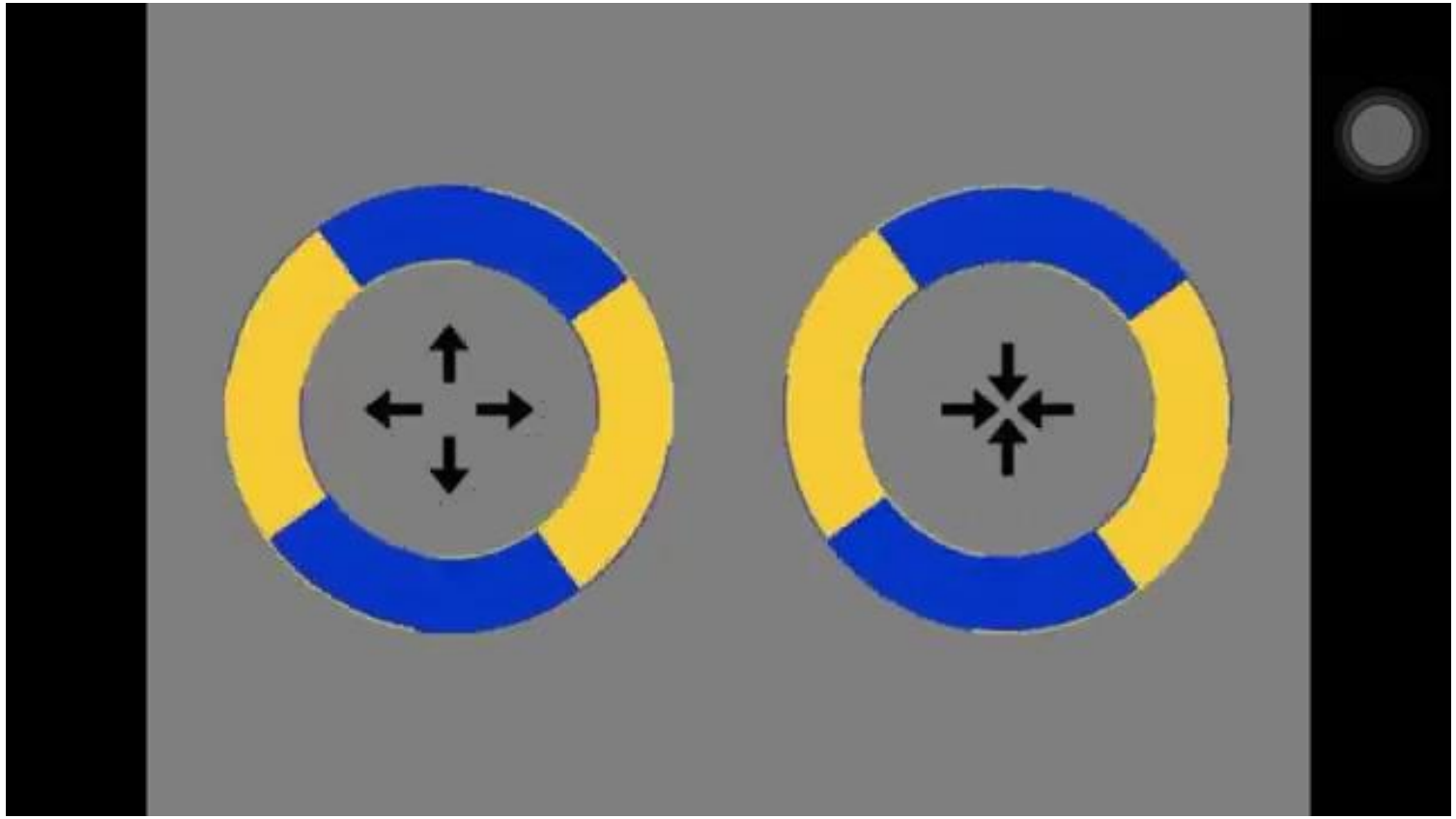


Optical Illusions





Optical Illusions



Summary - Human Visual System

visual acuity: 20/20 is ~1 arc min

field of view: ~200° monocular, ~120° binocular, ~135° vertical

resolution of eye: ~576 megapixels

temporal resolution: ~60 Hz (depends on contrast, luminance)

dynamic range: instantaneous 6.5 f-stops, adapt to 46.5 f-stops

colour: everything in CIE xy diagram

depth cues in 3D displays: vergence, focus, (dis)comfort

accommodation range: ~8cm to ∞, degrades with age

The perfect Retina Display

FOV: 200-220° x 135° needed (both eyes)

120° stereo overlap

Acuity: ~0.4 arc min (1 pixel/0.4 arc min)

Pixel Resolution: ~30,000 x 20,000 pixels

200*60°/0.4 = 30,000, 135*60°/0.4 = 20,250

Pixels/inch: > 2190 PPI @ 100mm (depends on distance to screen)

Update rate: 60 Hz

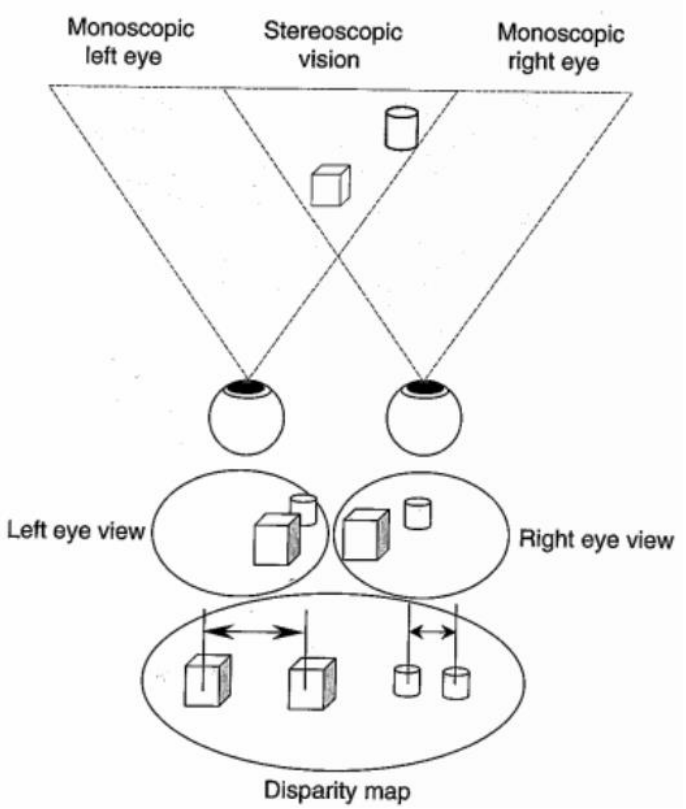
The biggest challenge:

- bandwidth compress and transmit huge amount of data drive and operate display pixels

Comparison

Aspect	Human Eyes	HTC Vive
FOV	200° x 135°	110° x 110°
Stereo Overlap	120°	110°
Resolution	30,000 x 20,000	2,160 x 1,200
Pixels/inch	>2190 (100mm to screen)	456
Update	60 Hz	90 Hz

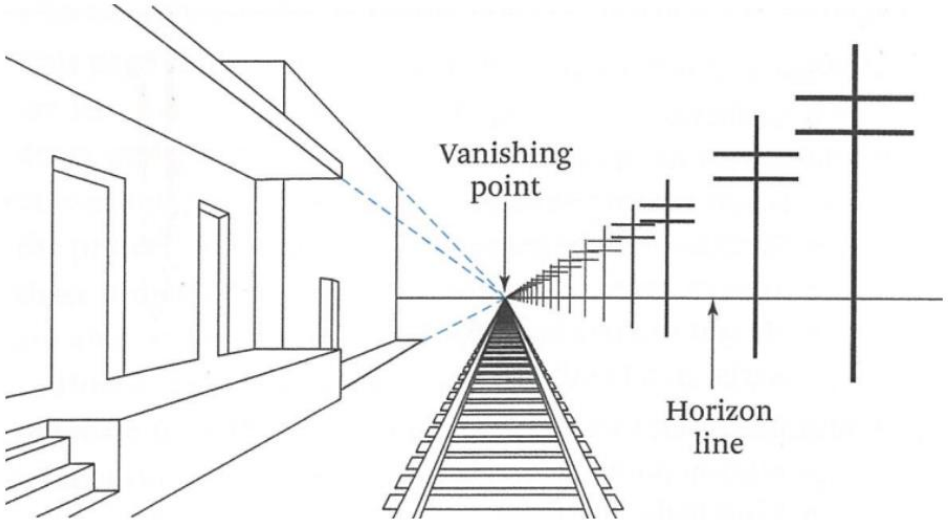
Depth Perception

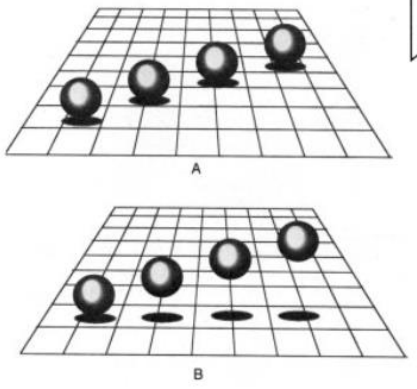


Motion Parallax

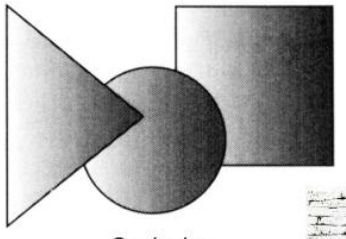
Stereo Pair

Depth Cues





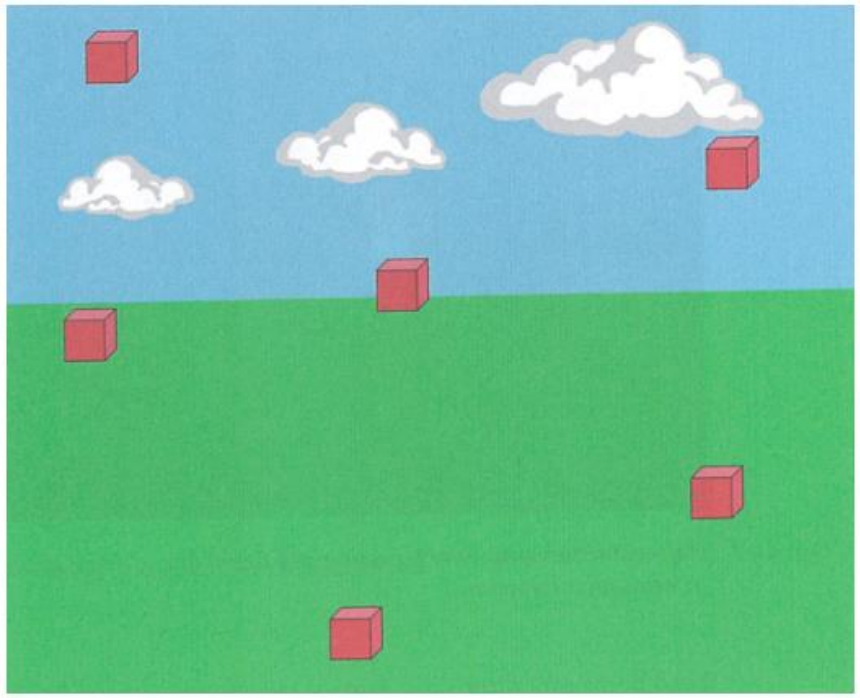
Shadows

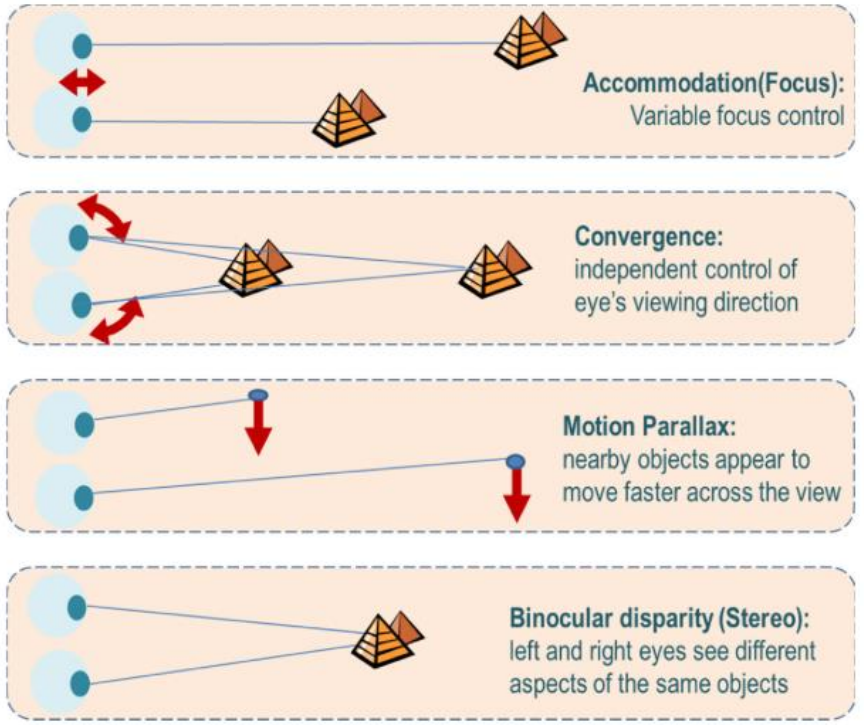


Occlusion

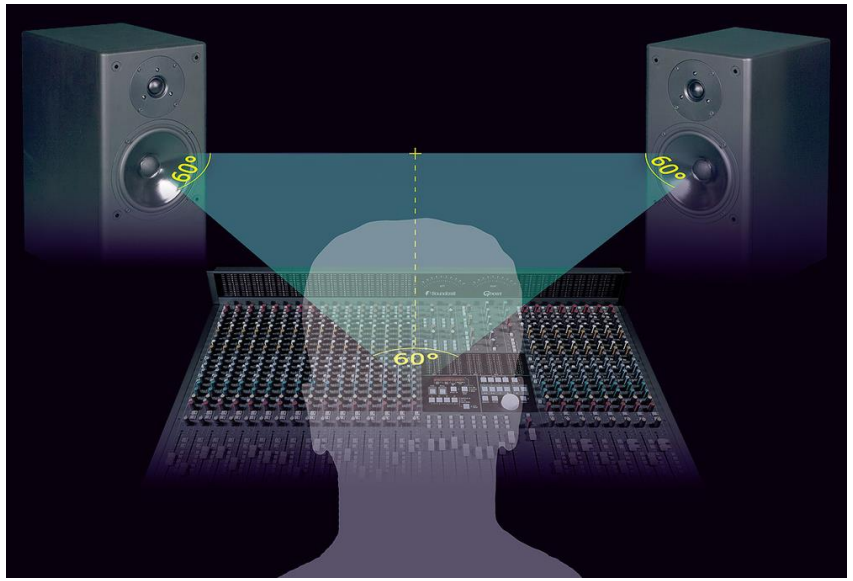
Texture Gradient

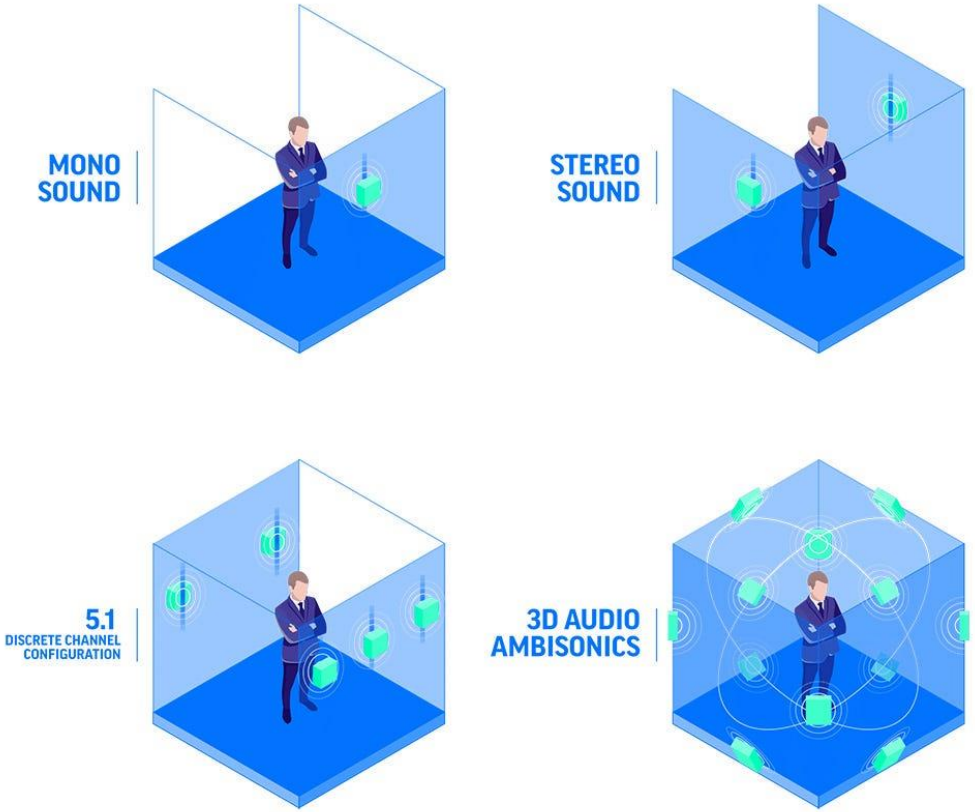
Depth Cues




Accommodation(Focus):
Variable focus control
Convergence:
independent control of
eye's viewing direction
Motion Parallax:
nearby objects appear to
move faster across the view
Binocular disparity (Stereo):
left and right eyes see different
aspects of the same objects

Audio

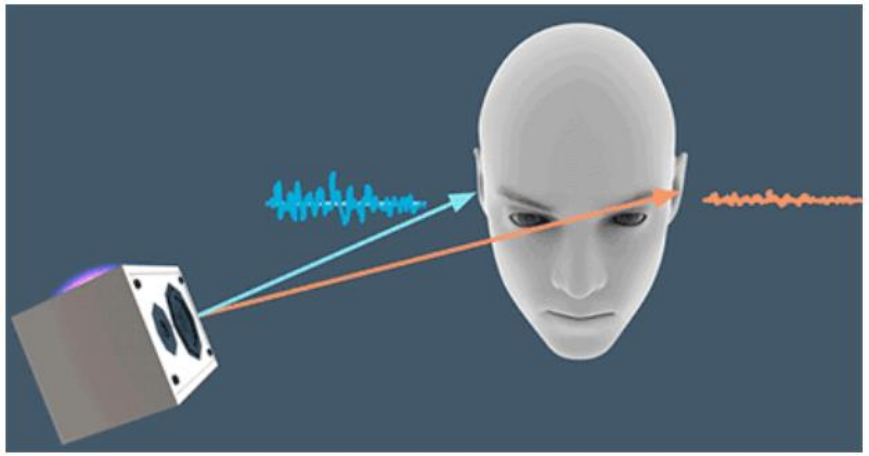

60°
60°
60°

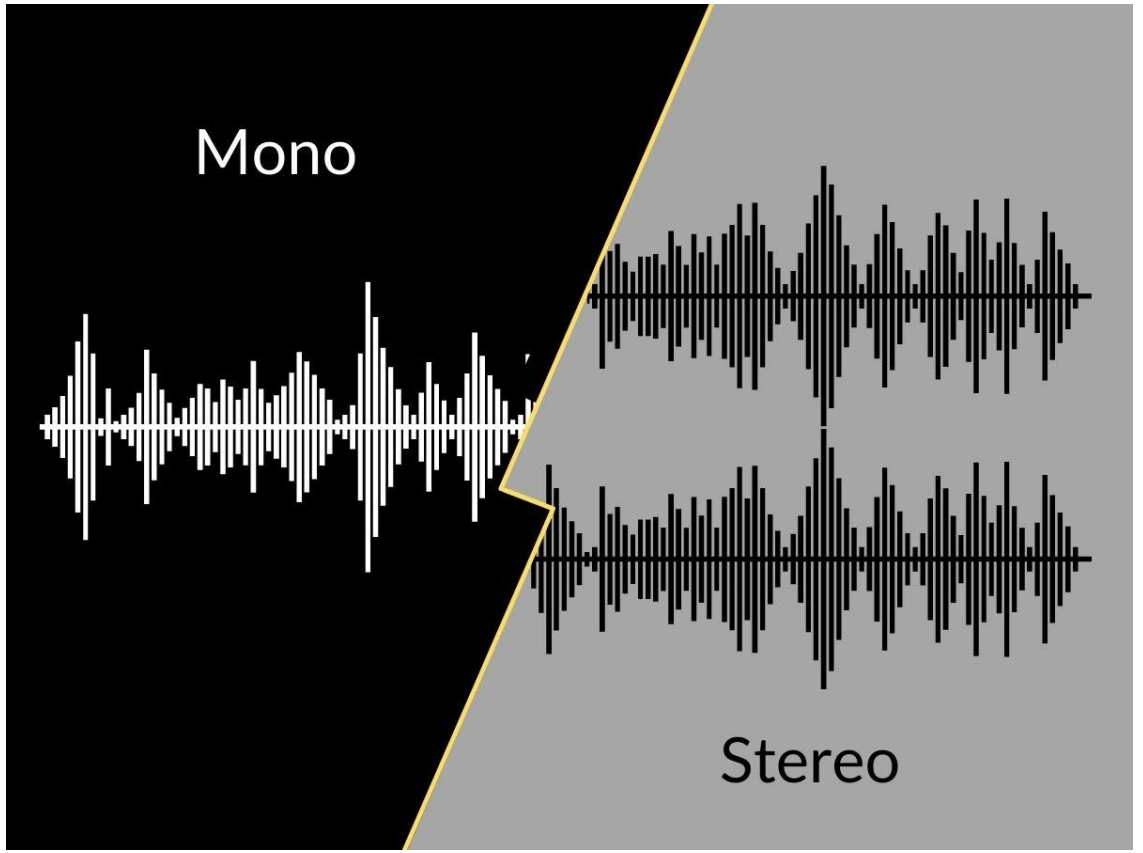

MONO SOUND
STEREO SOUND
5.1
DISCRETE CHANNEL CONFIGURATION
3D AUDIO AMBISONICS

Spatial Audio

https://www.youtube.com/watch?v=yUlnMbxTuY0

Audio





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Demo

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Key Technologies for VR Systems

Visual Display
- Stimulate visual sense

Audio/Tactile Display
- Stimulate hearing/touch

Tracking
- Changing viewpoint
- User input

Input Devices
- Supporting user interaction

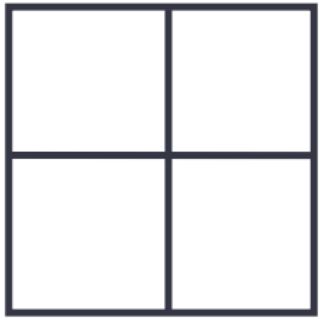
HMD Key Features

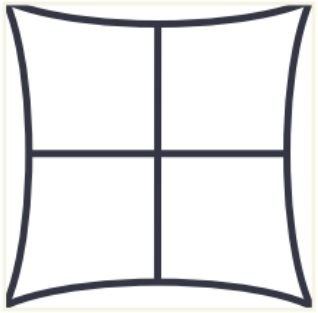
Lens
- Focal length, Field of View
- Occularity, Interpupillary distance
- Eye relief, Eye box

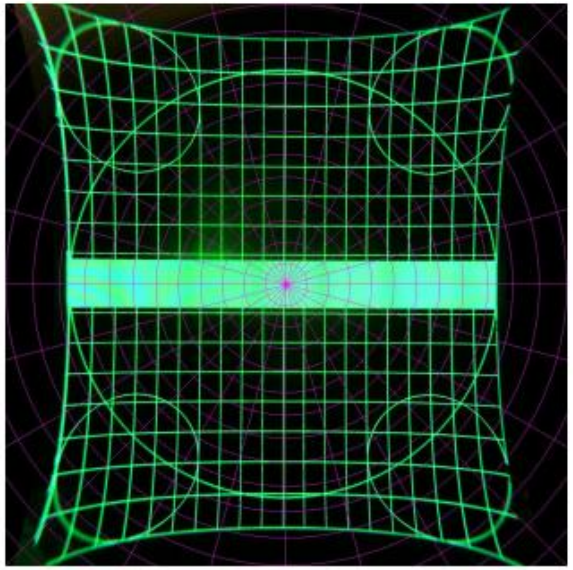
Display
- Resolution, contrast
- Power, brightness
- Refresh rate

Ergonomics
- Size, weight
- Wearability

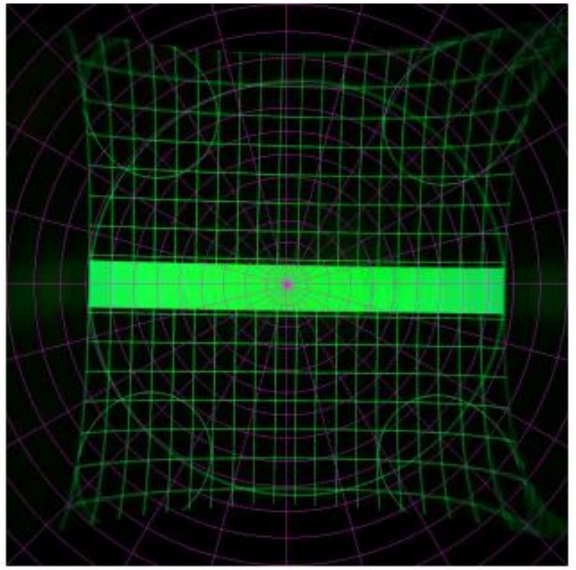
Distortion





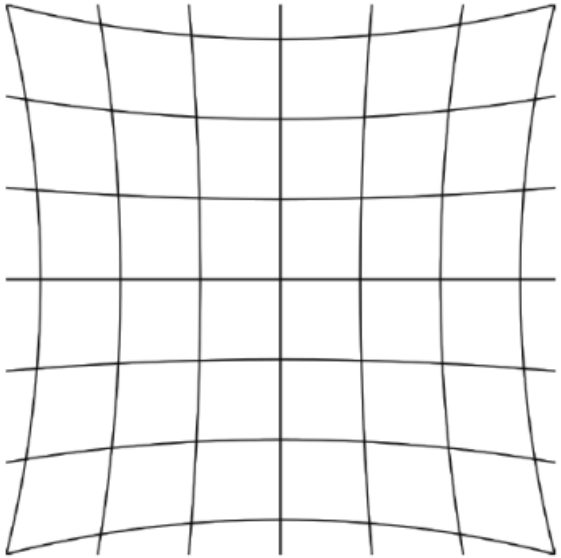


Oculus Rift DK2



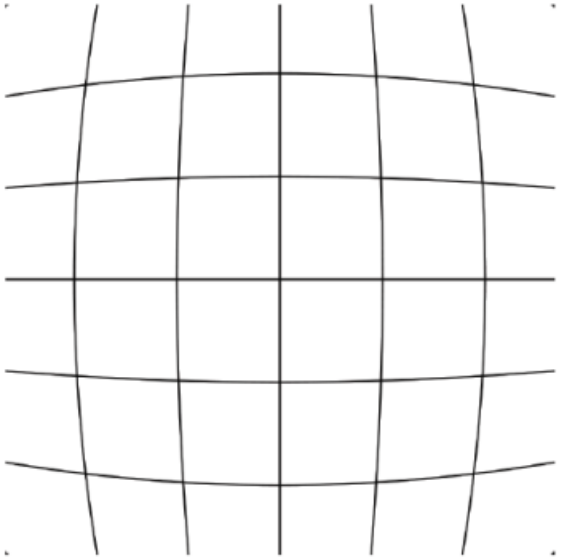
HTC Vive

Distortion



Pincussion Distortion

optical



Barrel Distortion

digital correction

Large Displays

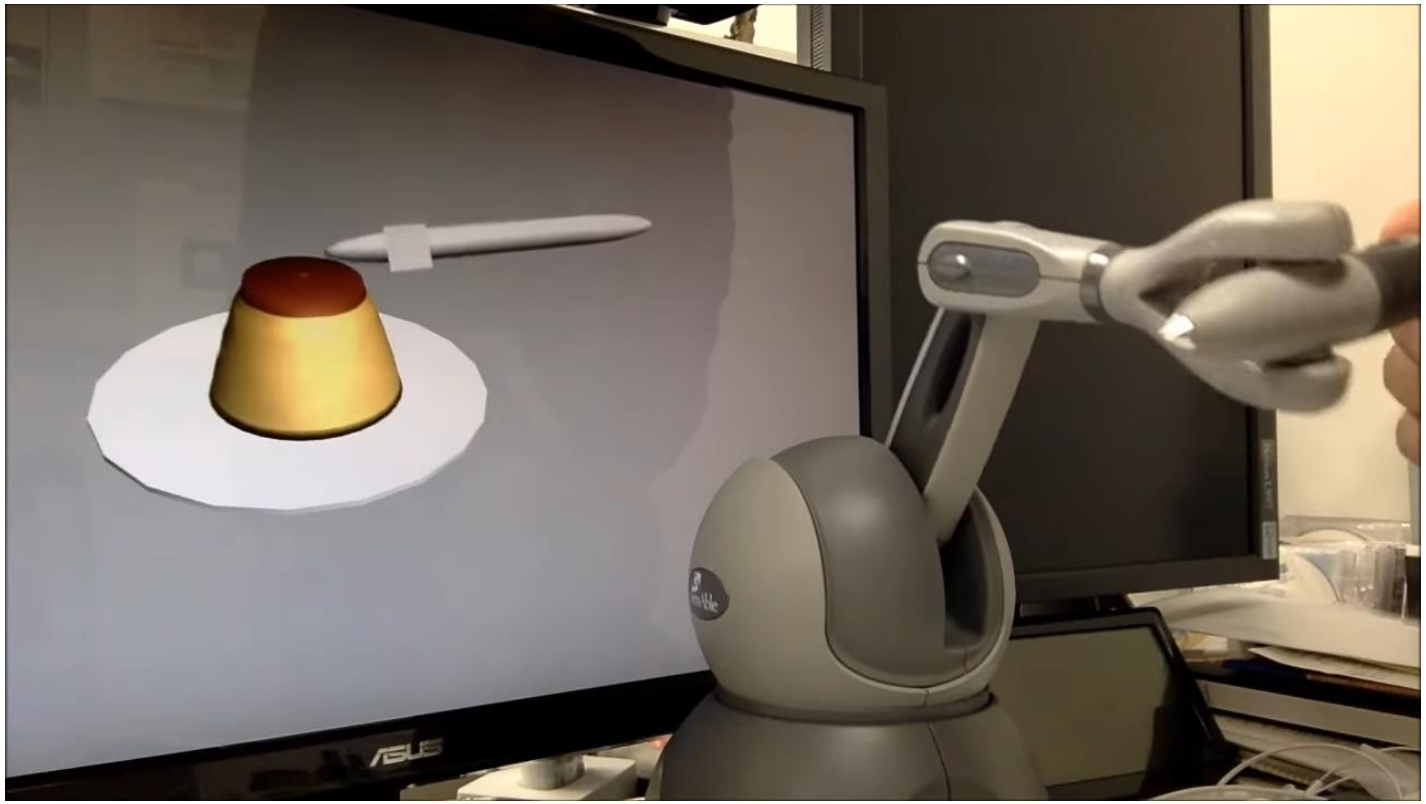
Room Scale Projection
- CAVE, multi-wall environment

Dome projection
- Hemisphere/spherical display
- Head/body inside

Vehicle Simulator
- Simulated visual display in windows

CAVE Demo

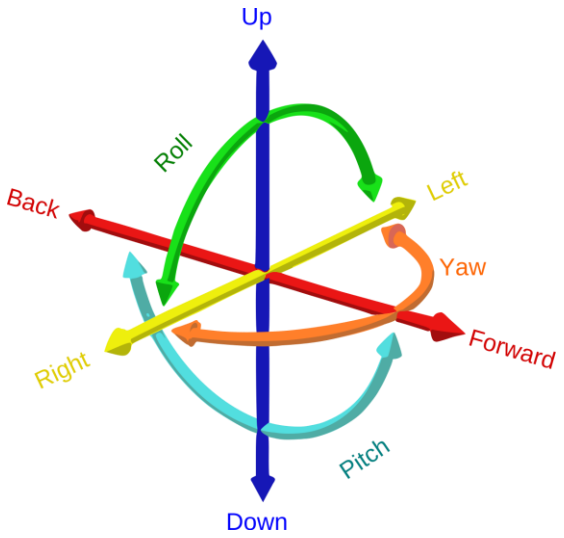
Tactile

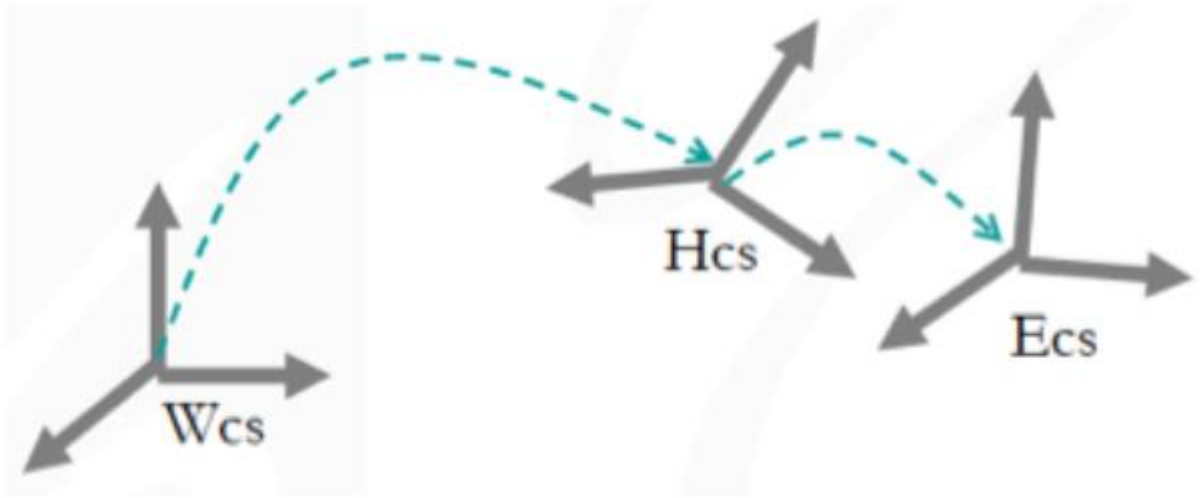


Tracking

Tracking: measuring the position and orientation of an object relative to a known frame of reference

VR Tracker: technology used in VR to measure the real time change in a 3D object position and orientation





Trackers

Mechanical
- Physical Linkage

Electromagnetic
- Magnetic sensing

Inertial
- Accelerometer, MEMs

Acoustic
- Ultrasonic

Optical
- Computer Vision

Hybrid

High-end Inertial sensors

Xsens

Physilog 5

Low-cost Inertial sensors

Sparkfun

WitMotion

Zstar3

Custom-made Inertial sensors

Lee et. al. [44]

Trackers

Vive Lighthouse