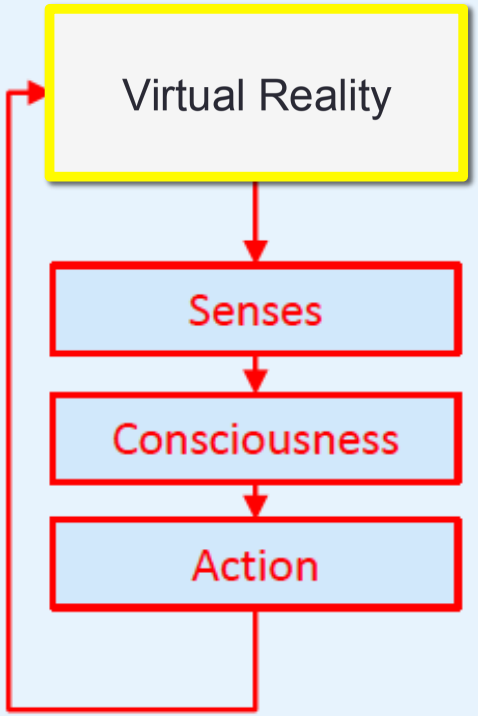
LECTURE 3: HUMAN PERCEPTION

ME/HCI 580

Virtual Reality Applications Center

Simple Sensing/Perception Model



Using VR to stimulate the senses

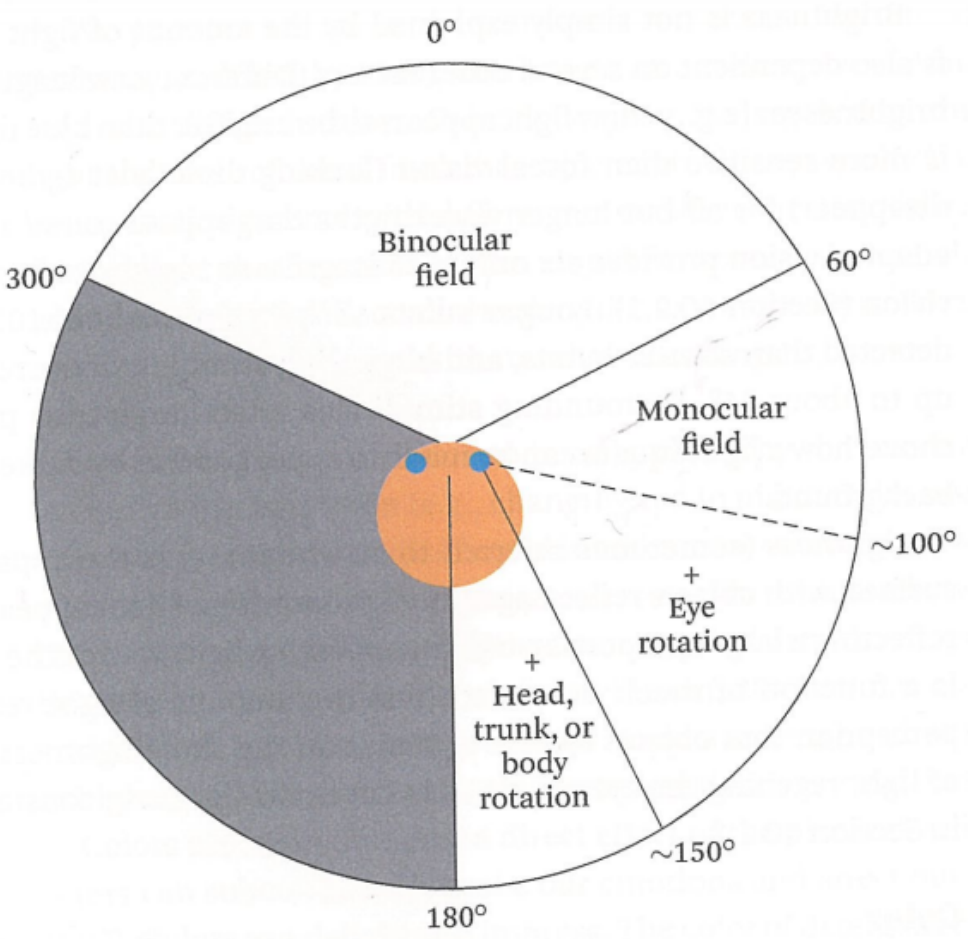
Senses

- How an organism obtains information for perception:
  - Sensation part of **Somatic Division** of **Peripheral Nervous System**
  - Integration and perception requires the **Central Nervous System**
- Five major senses:
  - Sight (Opthalamoception)
  - Hearing (Audioception)
  - Taste (Gustaoception)
  - Smell (Olfacaoception)
  - Touch (Tactioception)

Sight

Field of View

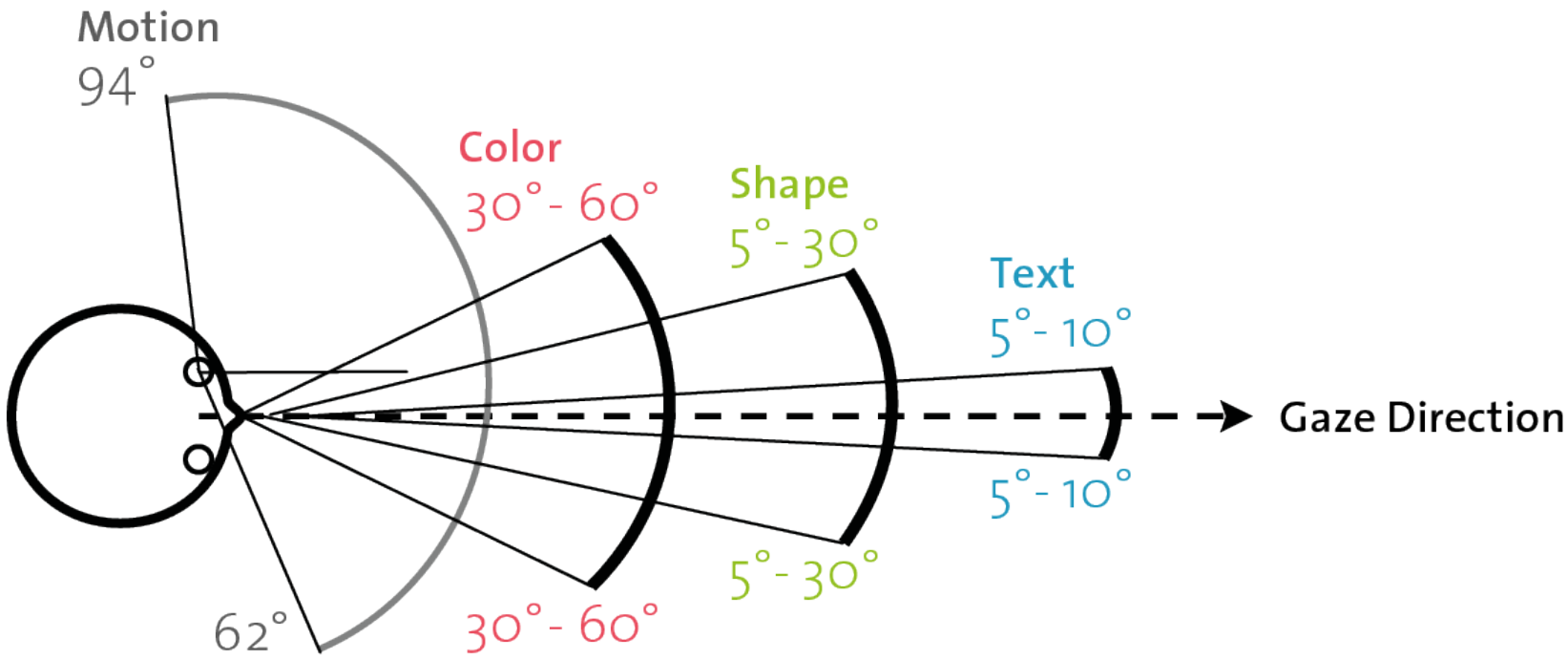
- Human frontal FOV
  - 100-110° horizontal per eye
  - Up to 200°-220° horizontal
    - Both eyes
  - 110°-120° stereo overlap
- Foveal Field
  - 60° horiz/vertically
  - Both eyes can see in focus



Field of View of Right Eye

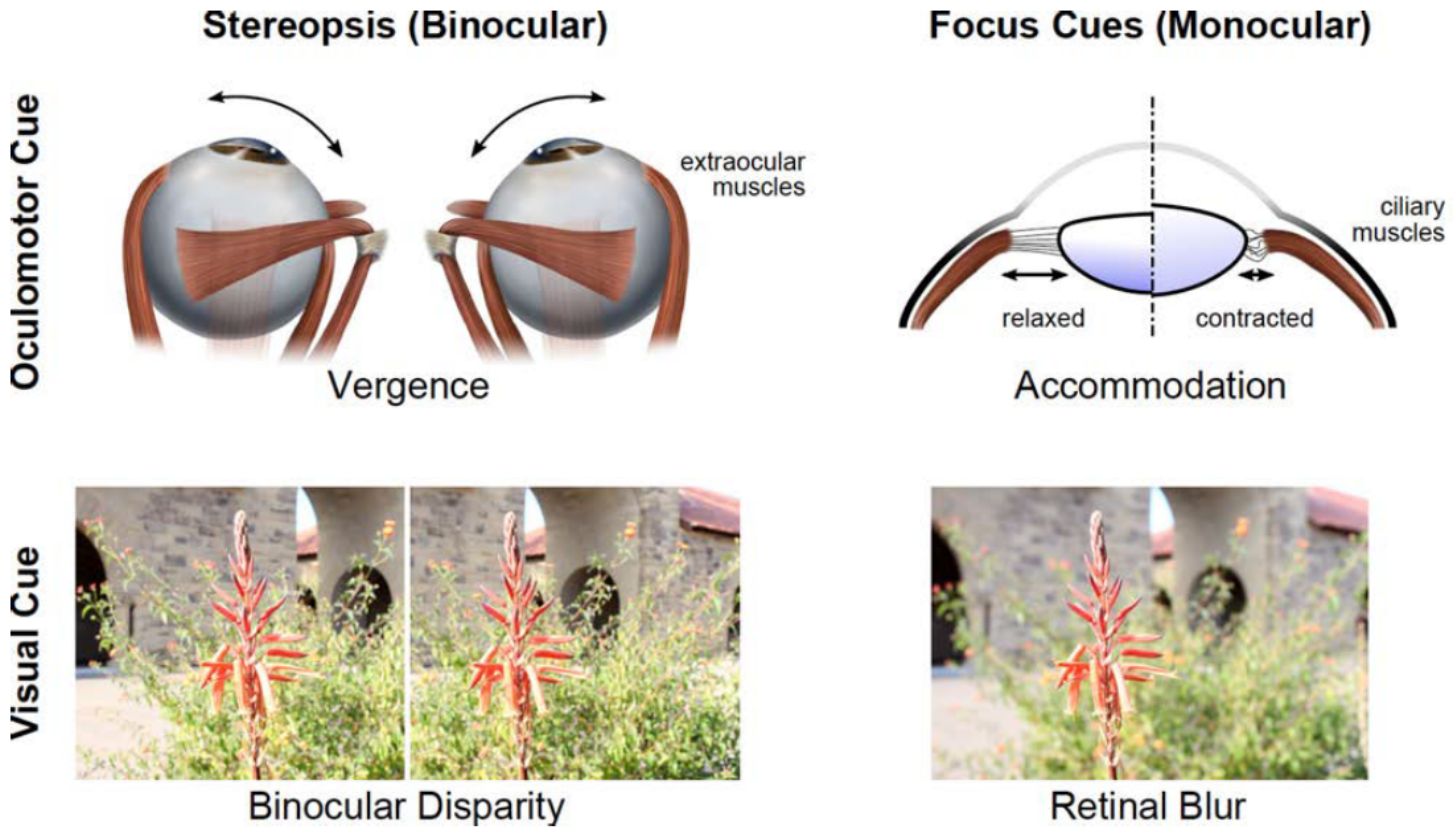
See https://vrwiki.wikispaces.com/Field+of+view

Types of Visible Perception Possible



- As move further from fovea, vision becomes more limited
- Colour vision only possible in central visual field

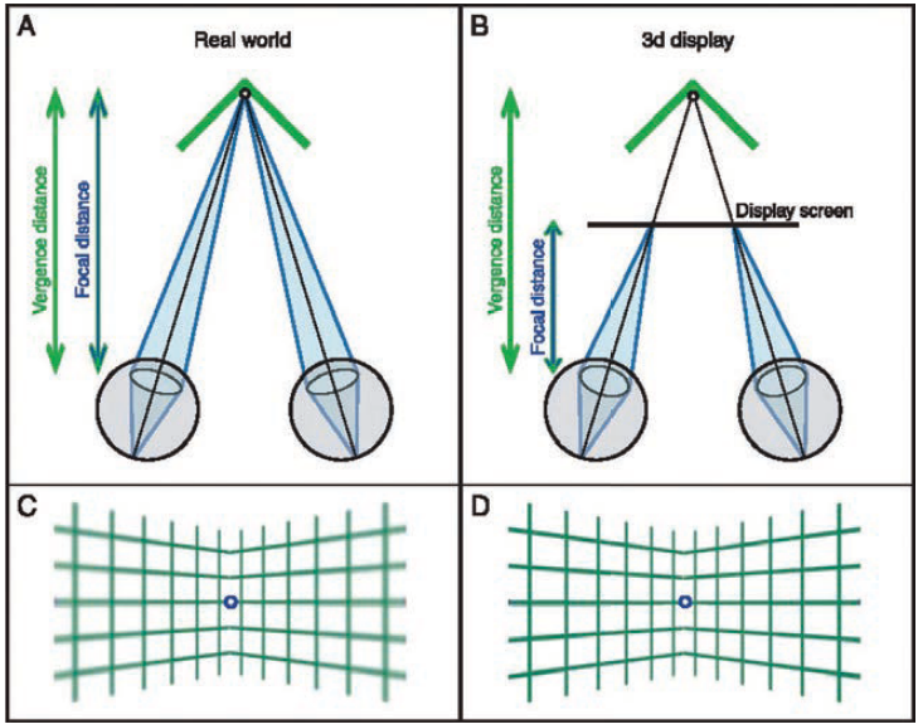
Vergence + Accommodation



- Vergence = eye rotation
- Accommodation = eye focusing

Vergence-Accommodation Conflict

Marty Banks, UC Berkeley



effects

- visual discomfort
- visual fatigue
- nausea
- diplopic vision
- eyestrain
- compromised image quality
- pathologies in developing visual system
- …

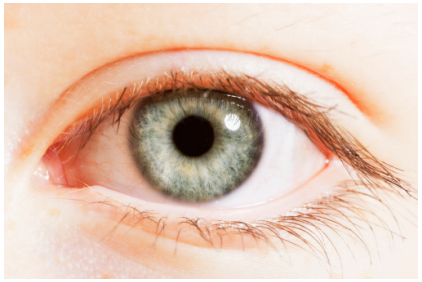
- Looking at real objects, vergence and focal distance match
- In Virtual Reality, vergence and accommodation can miss-match
  - Focusing on HMD screen, but accommodating for virtual object behind screen

The Perfect Retina Display

- A HMD capable of creating images indistinguishable from reality would need to match the properties of the eye:
  - 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 between Eyes and HMD



	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

See http://doc-ok.org/?p=1414
http://www.clarkvision.com/articles/eye-resolution.html
http://wolfcrow.com/blog/notes-by-dr-optoglass-the-resolution-of-the-human-eye/

Depth Perception

- The visual system uses a range of different Stereoscopic and Monocular cues for depth perception

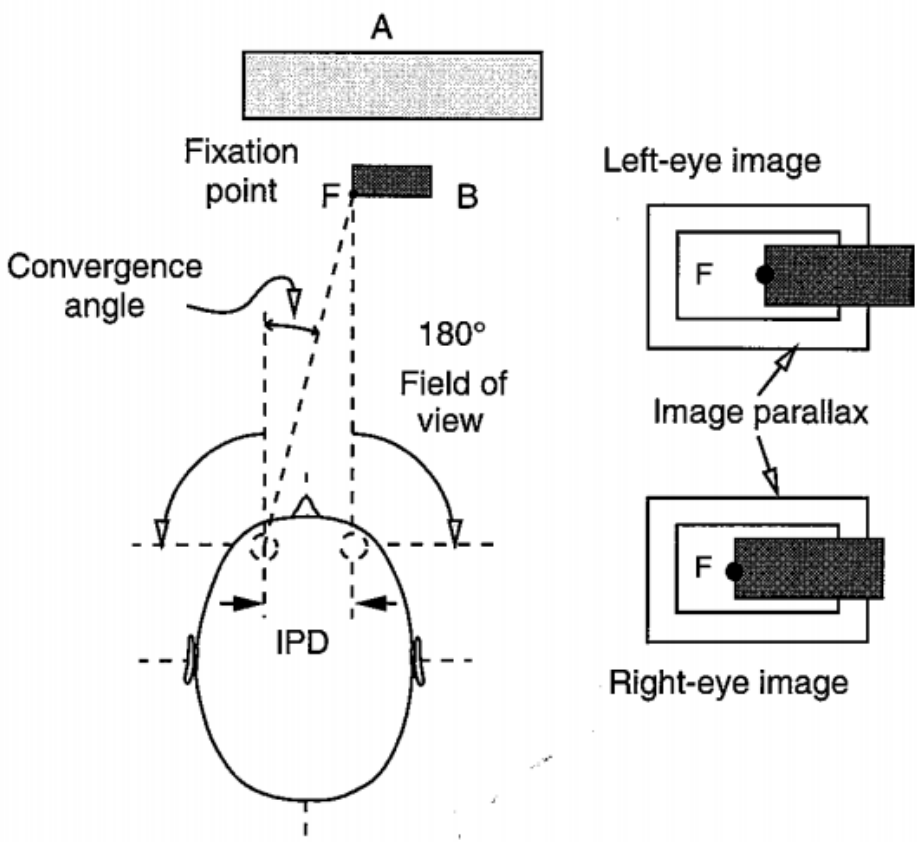
Stereoscopic	Monocular
eye convergence angle disparity between left and right images diplopia	eye accommodation perspective atmospheric artifacts (fog) relative sizes image blur occlusion motion parallax shadows texture

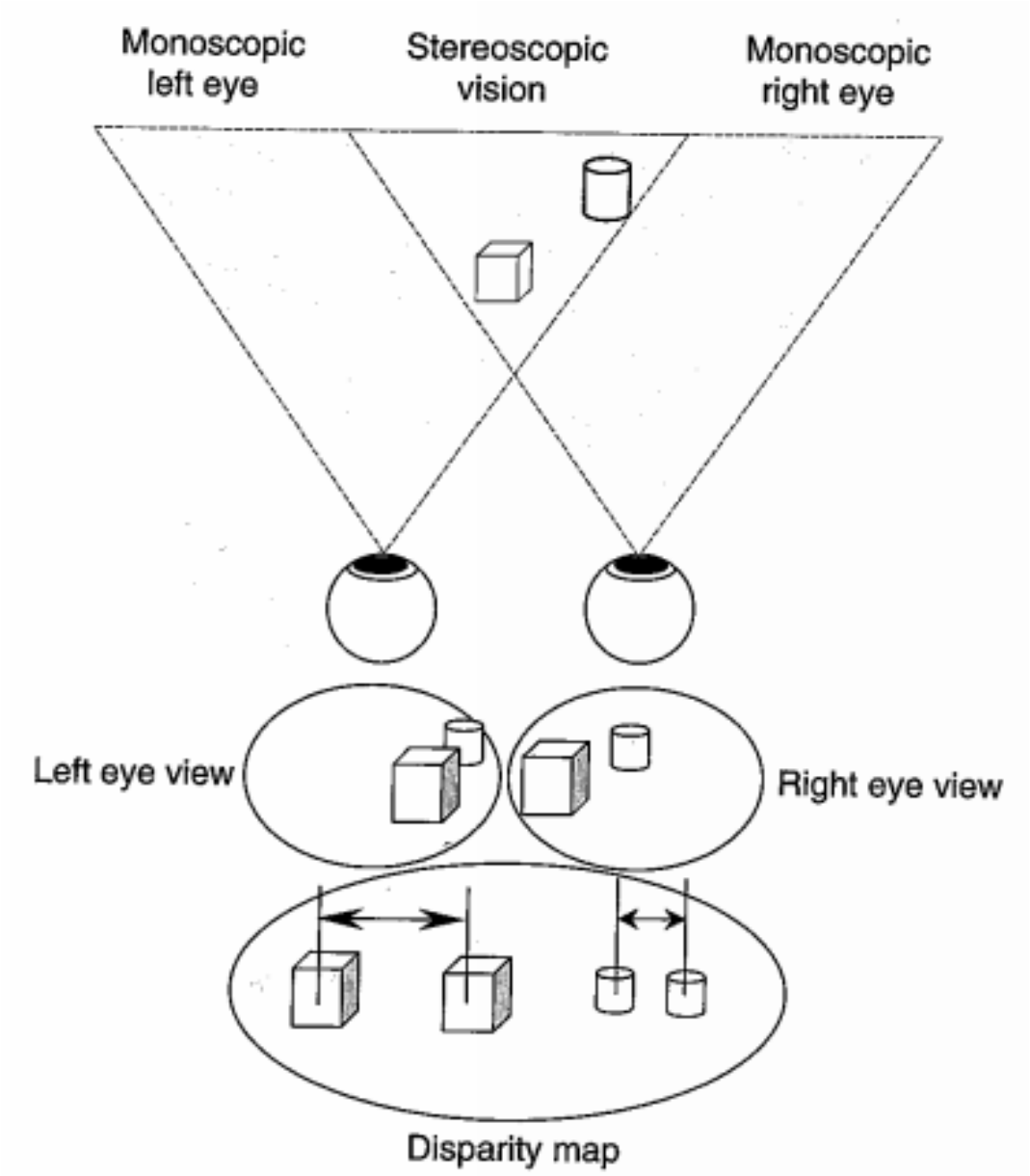
Parallax can be more important for depth perception!

Stereoscopy is important for size and distance evaluation

Stereo Perception/Stereopsis

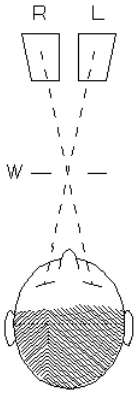
- Eyes separated by IPD
  - Inter pupillary distance
  - 5 – 7.5cm (average. 6.5cm)
- Each eye sees diff. image
  - Separated by image parallax
- Images fused to create 3D stereo view




Monoscopic
left eye
Stereoscopic
vision
Monoscopic
right eye
Left eye view
Right eye view
Disparity map

Stereo Pairs

- 3D image formed by two separate views
- Cross eyes to view



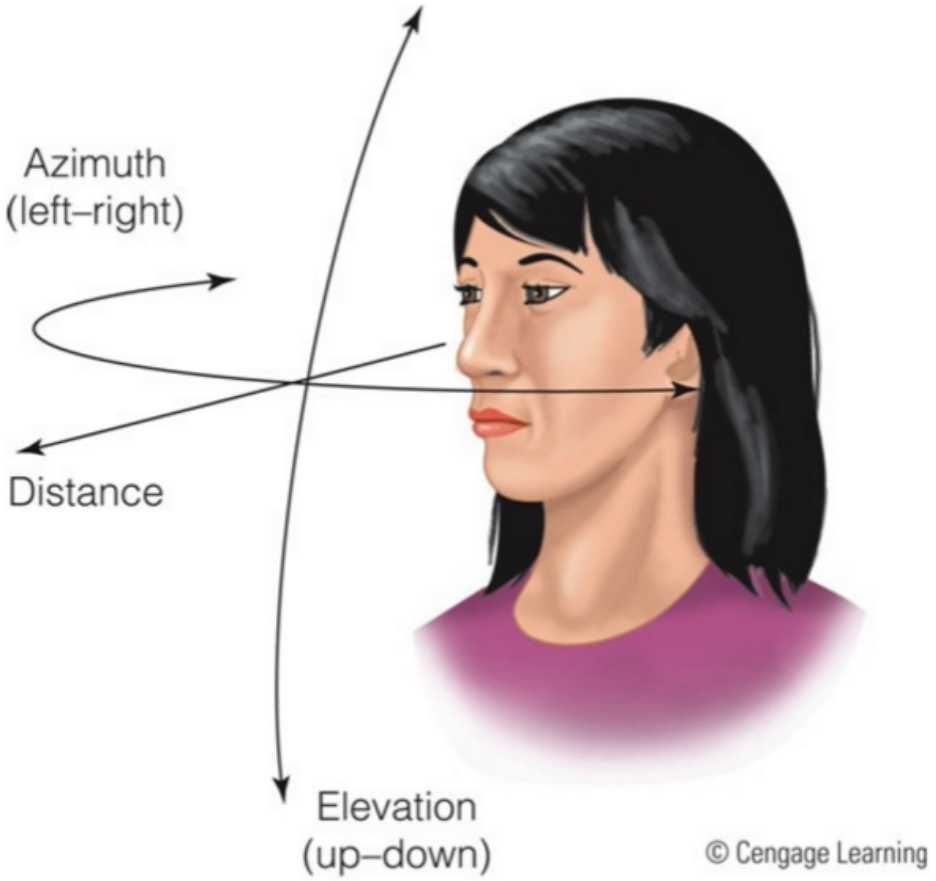
Other Depth Cues

- Focus effects – blurring of objects
- Haze – hazier objects more distant
- Colour – bluish objects more distant
- Motion Dynamics – objects in relative motion
- Perspective – change in relative size
- Texture – becomes smaller further away
- Prior knowledge – known size of obejcts
- Occlusion
- Shadows
- Etc


Hearing

Sound Localization

- Humans have two ears
  - localize sound in space
- Sound can be localized using 3 coordinates
  - Azimuth, elevation, distance

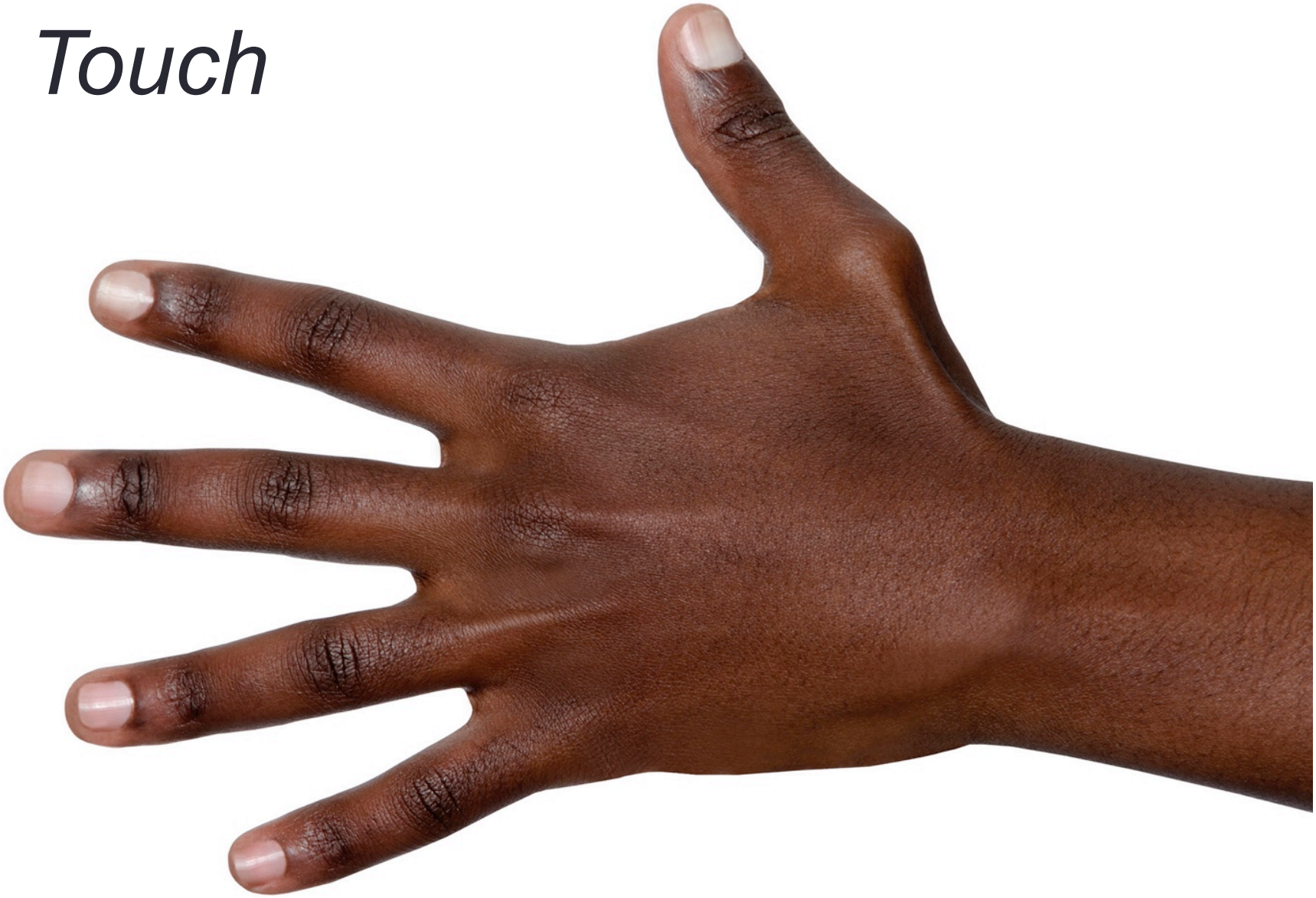


Accuracy of Sound Localization

- People can locate sound
  - Most accurately in front of them
    - 2-3° error in front of head
  - Least accurately to sides and behind head
    - Up to 20° error to side of head
    - Largest errors occur above/below elevations and behind head
- Front/back confusion is an issue
  - Up to 10% of sounds presented in the front are perceived coming from behind and vice versa (more in headphones)

BUTEAN, A., Bălan, O., NEGOI, I., Moldoveanu, F., & Moldoveanu, A. (2015). COMPARATIVE RESEARCH ON SOUND LOCALIZATION ACCURACY IN THE FREE-FIELD AND VIRTUAL AUDITORY DISPLAYS. In*Conference proceedings of» eLearning and Software for Education «(eLSE)*(No. 01, pp. 540-548). Universitatea Nationala de Aparare Carol I.

Touch



Touch

- Mechanical/Temp/Pain stimuli transduced into Action Potentials (AP)
- Transducing structures are specialized nerves:
  - Mechanoreceptors: Detect pressure, vibrations & texture
  - Thermoreceptors: Detect hot/cold
  - Nocireceptors: Detect pain
  - Proprioreceptors: Detect spatial awareness
- This triggers an AP which then travels to various locations in the brain via the somatosensory nerves

Spatial Resolution

- Sensitivity varies greatly
  - Two-point discrimination

Body Site	Threshold Distance
Finger	2-3mm
Cheek	6mm
Nose	7mm
Palm	10mm
Forehead	15mm
Foot	20mm
Belly	30mm
Forearm	35mm
Upper Arm	39mm
Back	39mm
Shoulder	41mm
Thigh	42mm
Calf	45mm

http://faculty.washington.edu/chudler/chsense.html