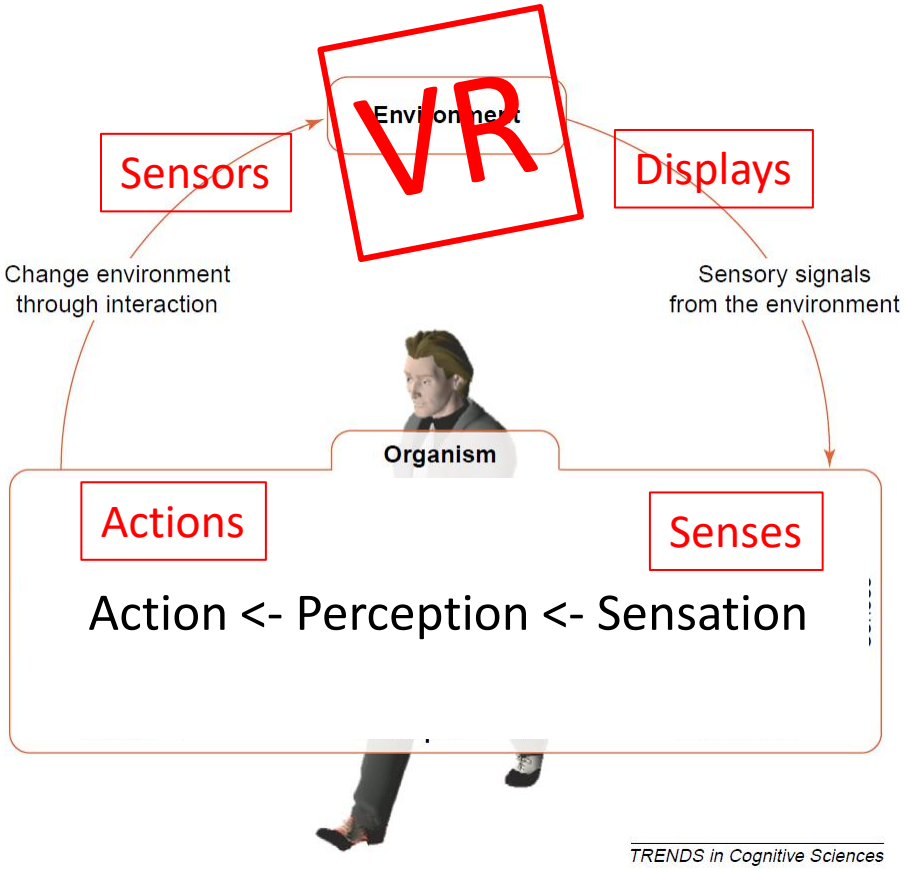
Human-machine interaction in virtual reality

Paul MacNeilage, Psychology
Eelke Folmer, Computer Science

Human-VR Loop

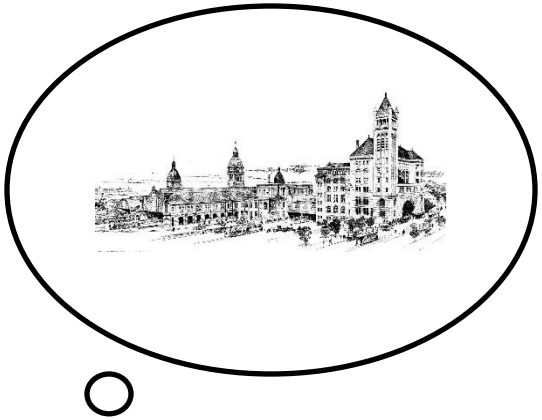


Ernst & Bulthoff 2004

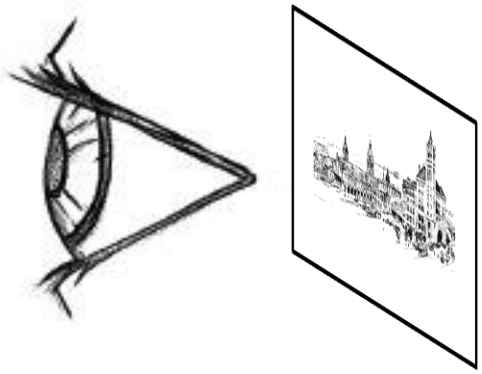
Extract Critical Features

- Depth
- Color
- Motion
- Etc.

Perceptual Reconstruction



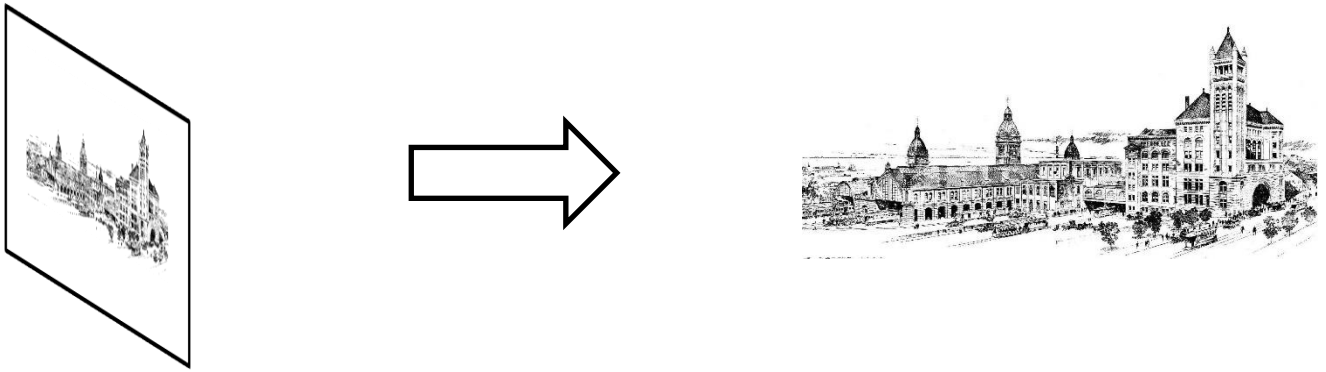
3D Real world



2D Image

Inverse Problem

- Solution is underconstrained



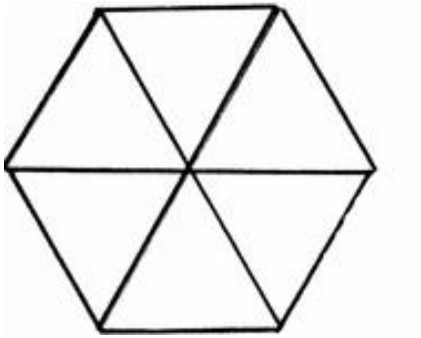
2D Image

Percept of the world

- Must infer solution; extract information
- Rely on reasonable assumptions

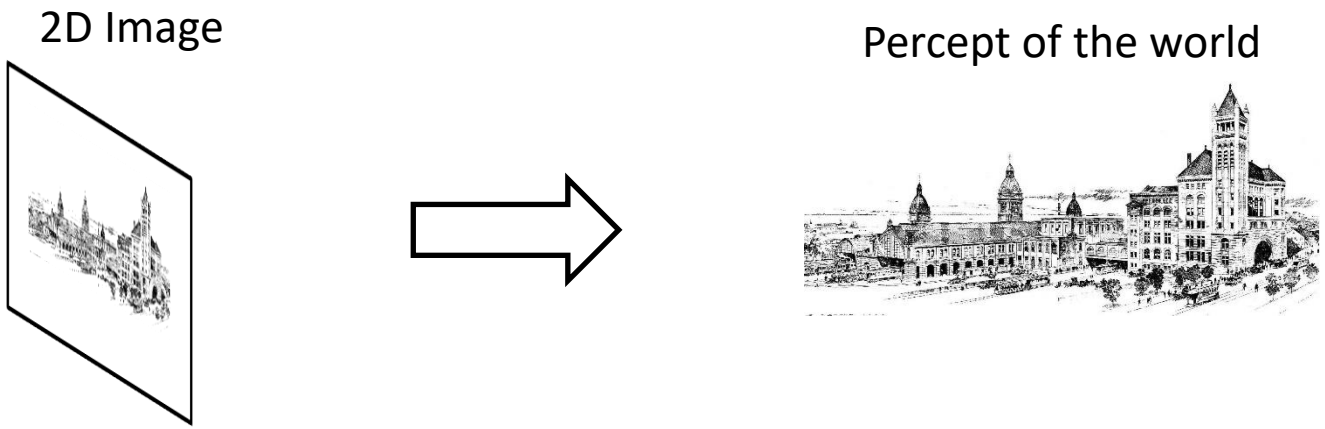
Perception as Inference

- Illusions illustrate assumptions…

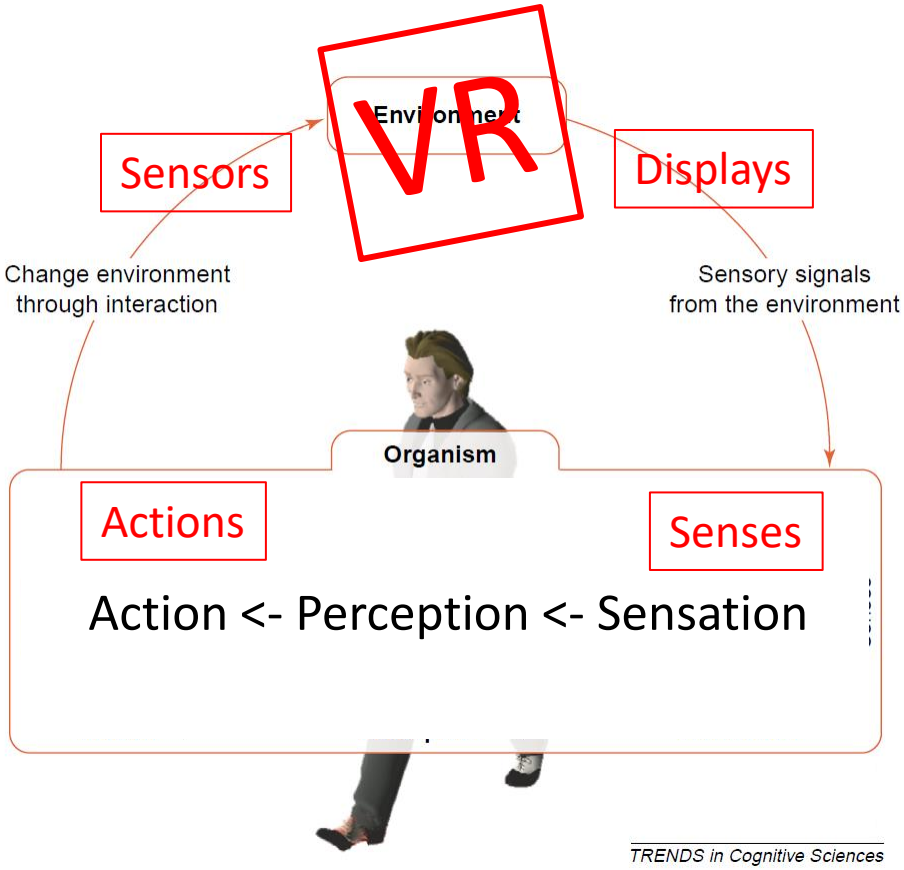


Perceptual Science

1) Sensory cues: identify sensory information available to the system
2) Assumptions: identify probabilistic information
3) Test how perception depends on these



Human-VR Loop

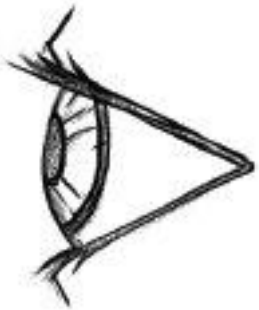


Ernst & Bulthoff 2004

Unity

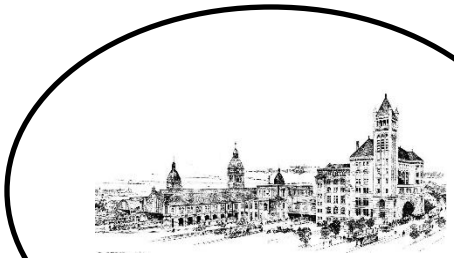
3D Model of the World

Unity



2D Image

Perceptual Reconstruction



Perceiving Depth or Distance

- Important for perception of shape and scene layout

- Depth – can be relative (nearer vs farther)
- Distance – absolute, metric

- Types of sensory cues:
  - Pictorial (monocular)
  - Stereo (binocular)
  - Parallax (motion)
  - Accommodation

Pictorial Cues?

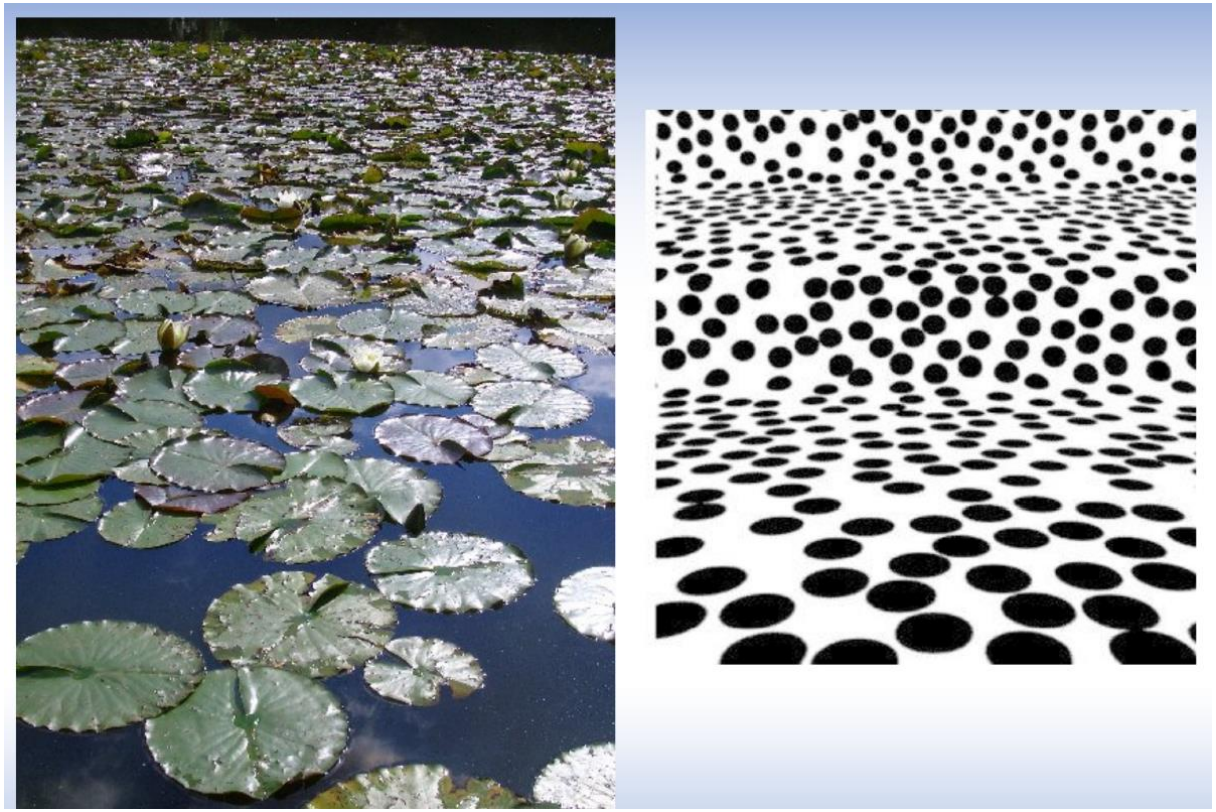
Perspective

- Lines converging in the distance

Vanishing point

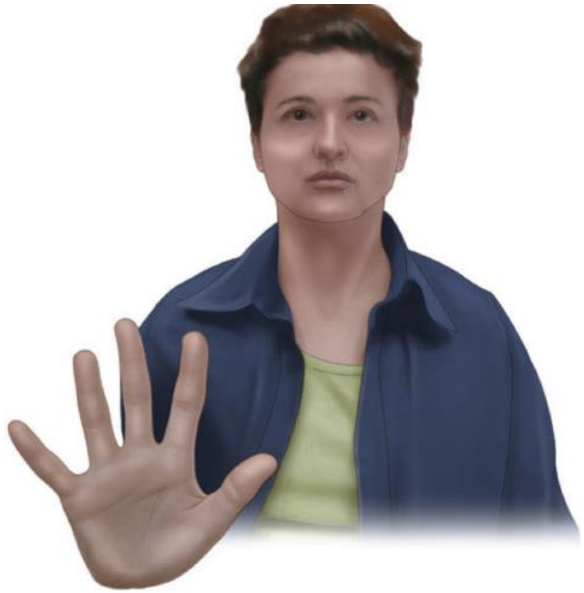
Texture Gradients

- Cue to surface slant; change in texture size with distance

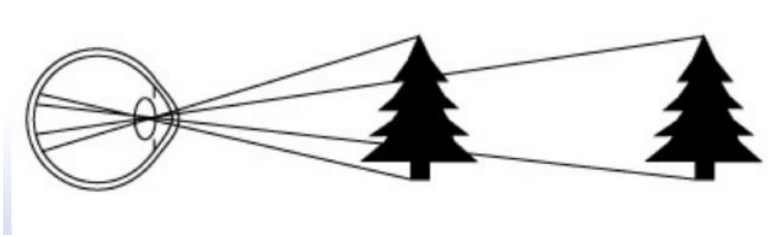


Size

- Absolute and relative

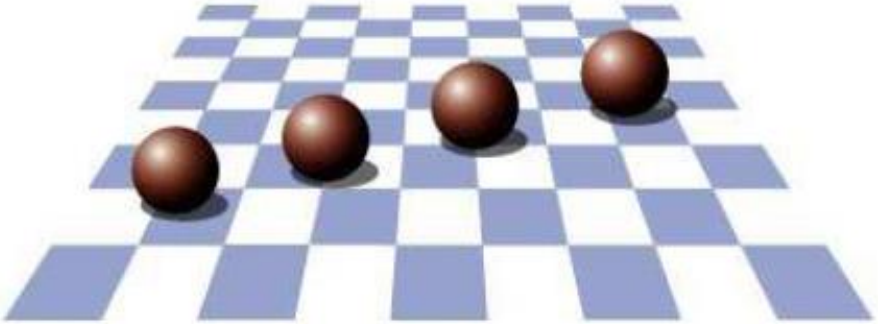


SENSATION & PERCEPTION 3e, Figure 6.12



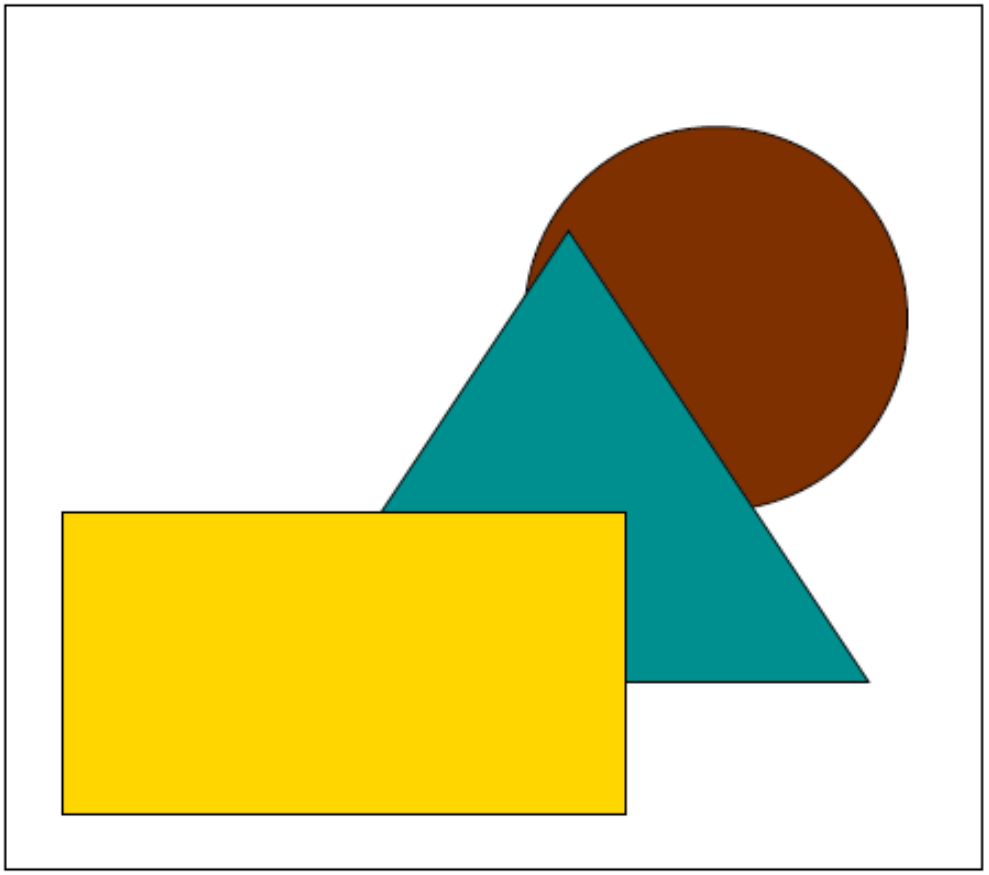
All of the Above

Elevation



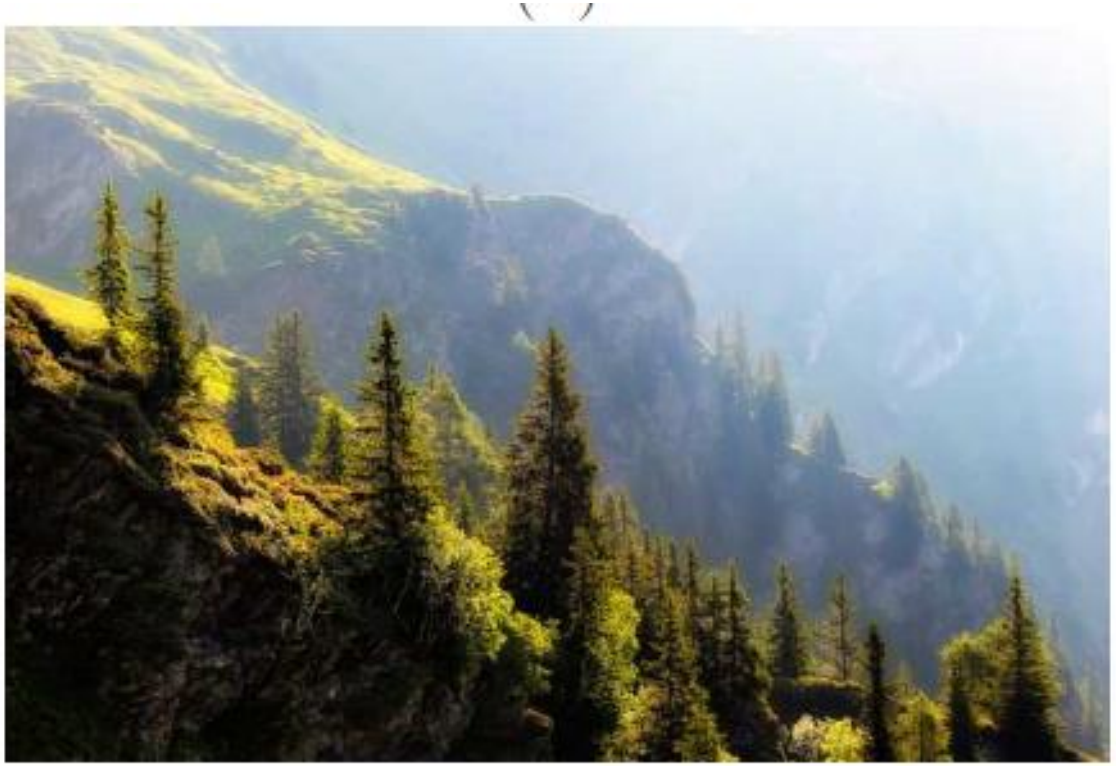
Occlusion

- a.k.a. Occultation, Interposition



Atmospheric Cue

- a.k.a. aerial perspective



Defocus / Blur

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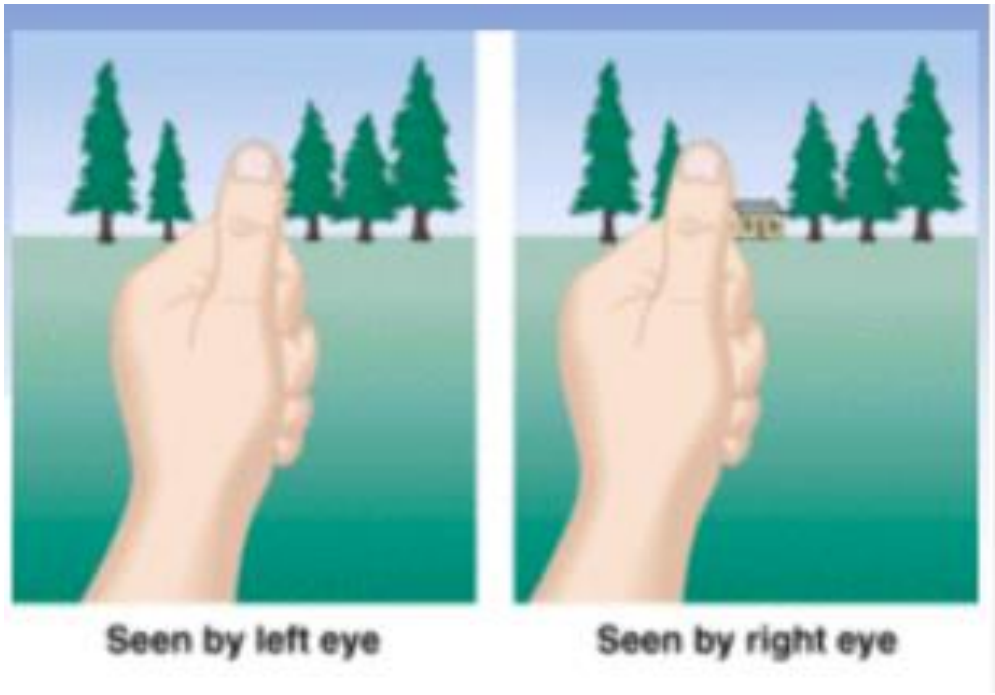
  - Accommodation

Stereopsis

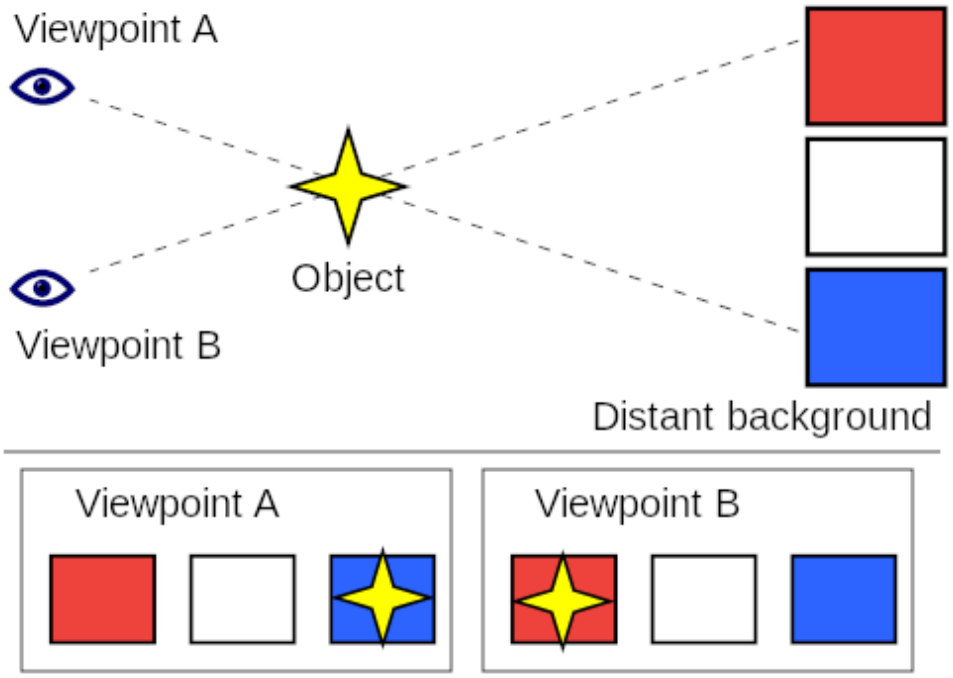
- Slightly different images on left/right eyes



- This is the main driver of stereo (solid) vision

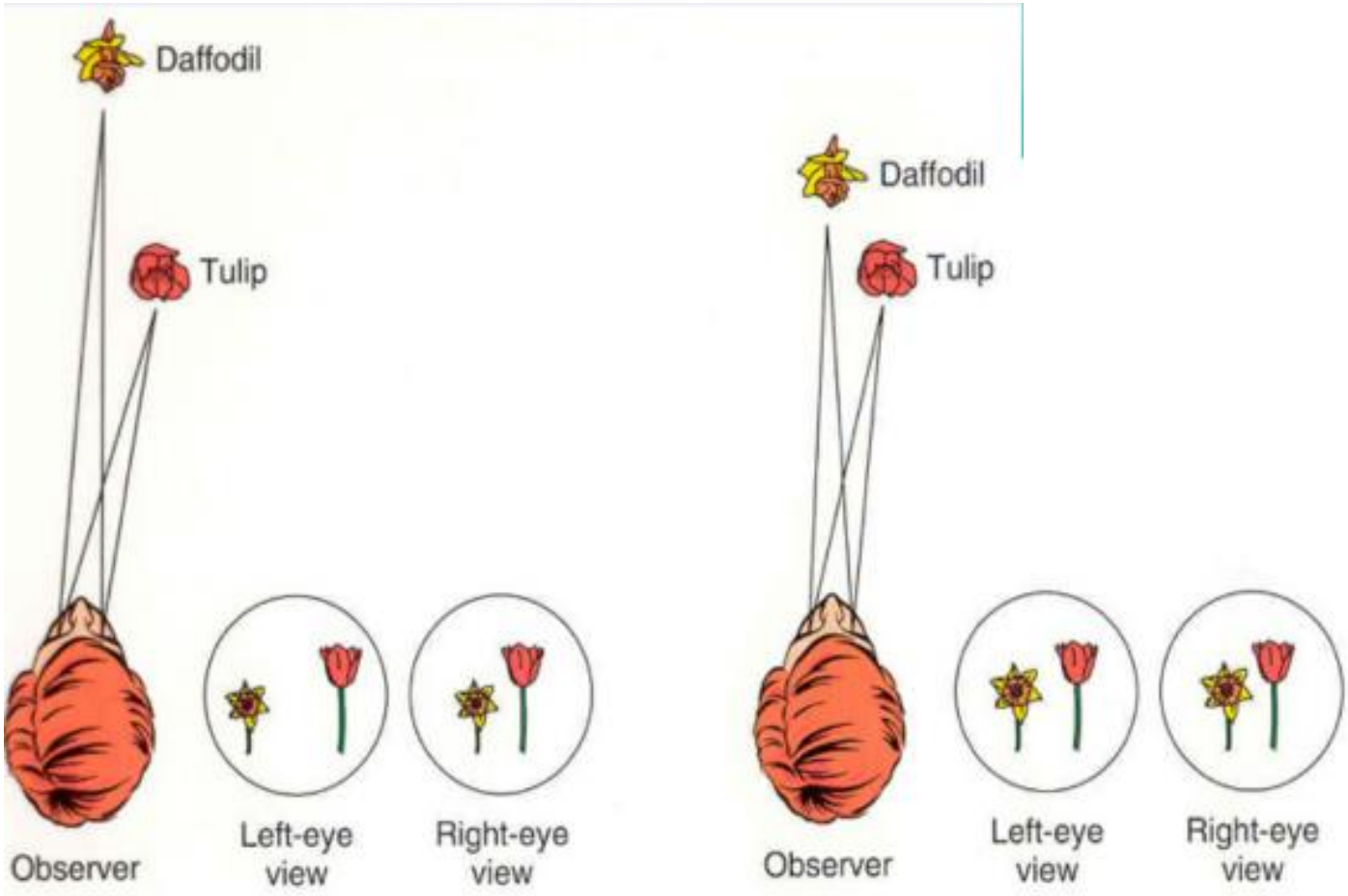
Stereopsis

- Depth is reconstructed from two views of the scene



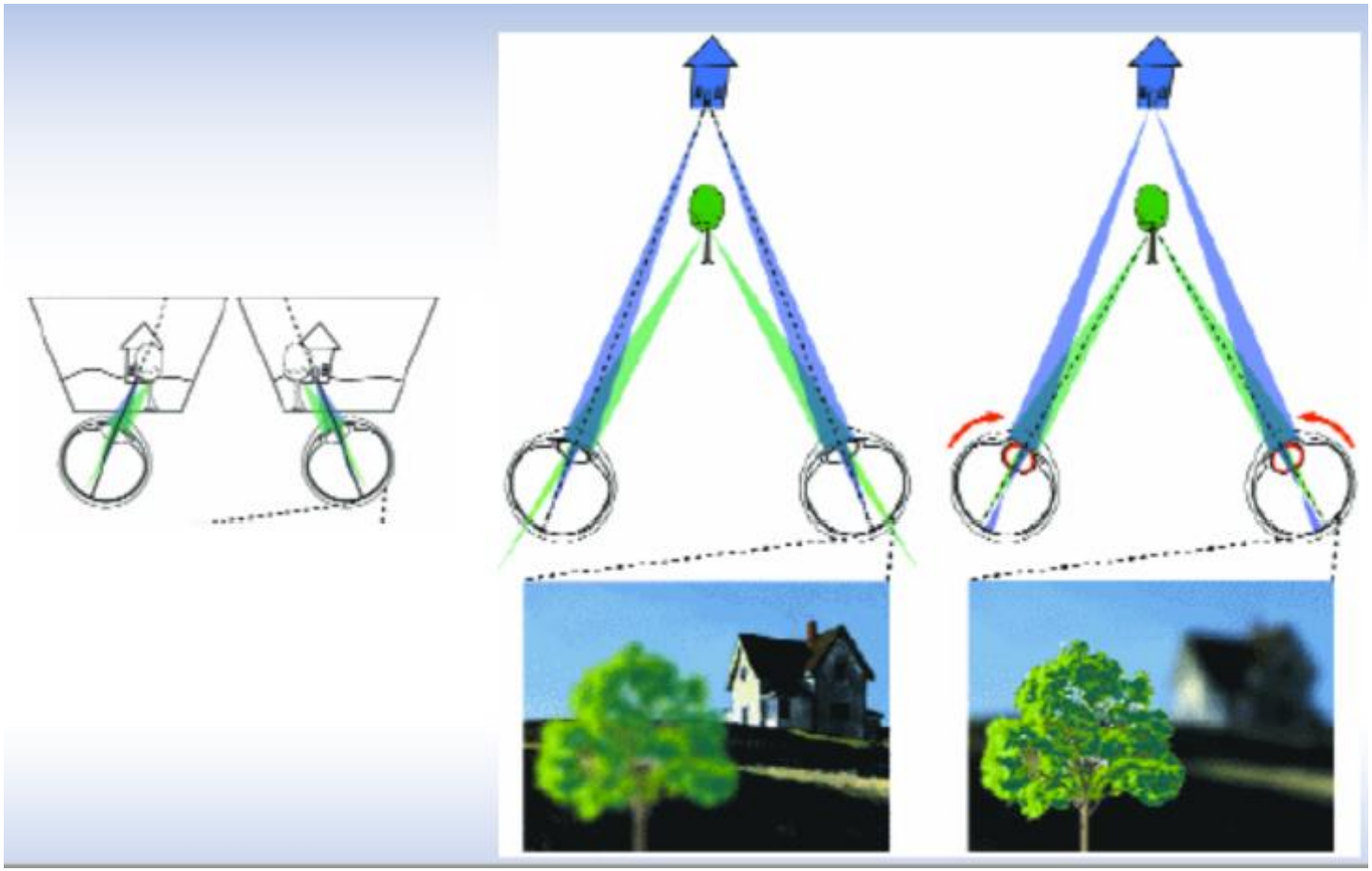
Stereopsis

- Disparity is a cue to *relative* depth separation



Stereopsis

- Vergence allows absolute distance scaling



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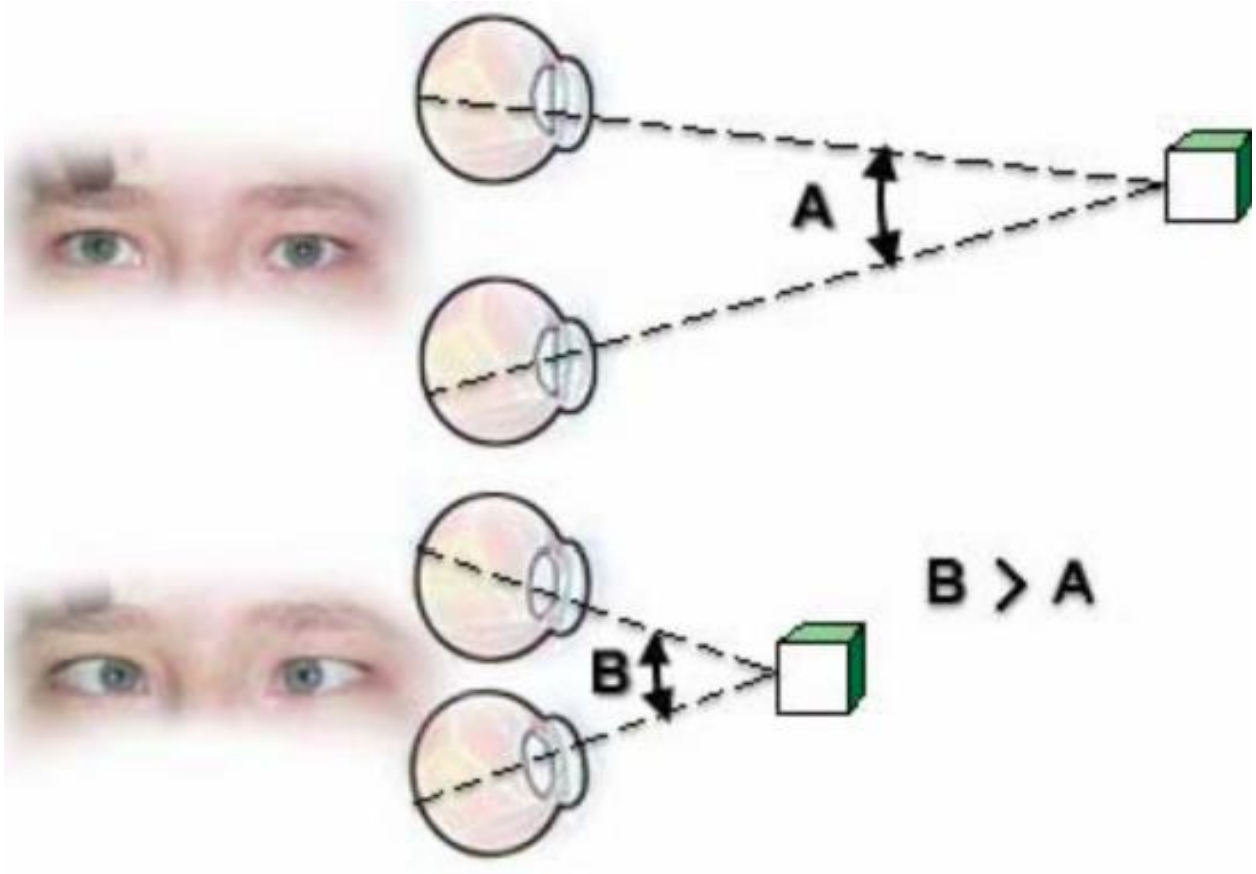
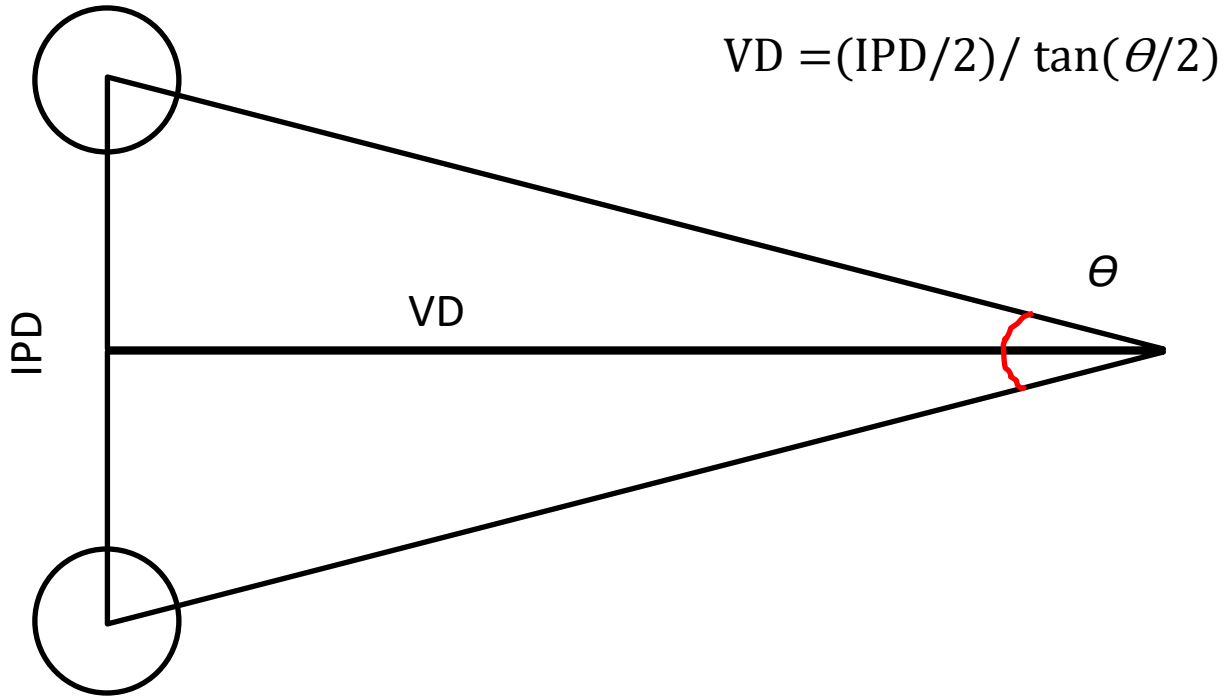


Stereopsis

- Scaling (viewing distance; VD) depends on interpupilary distance (IPD)



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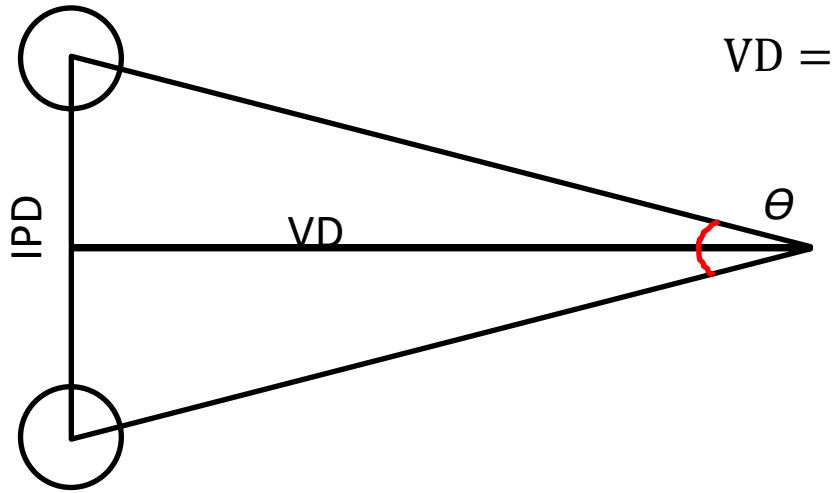
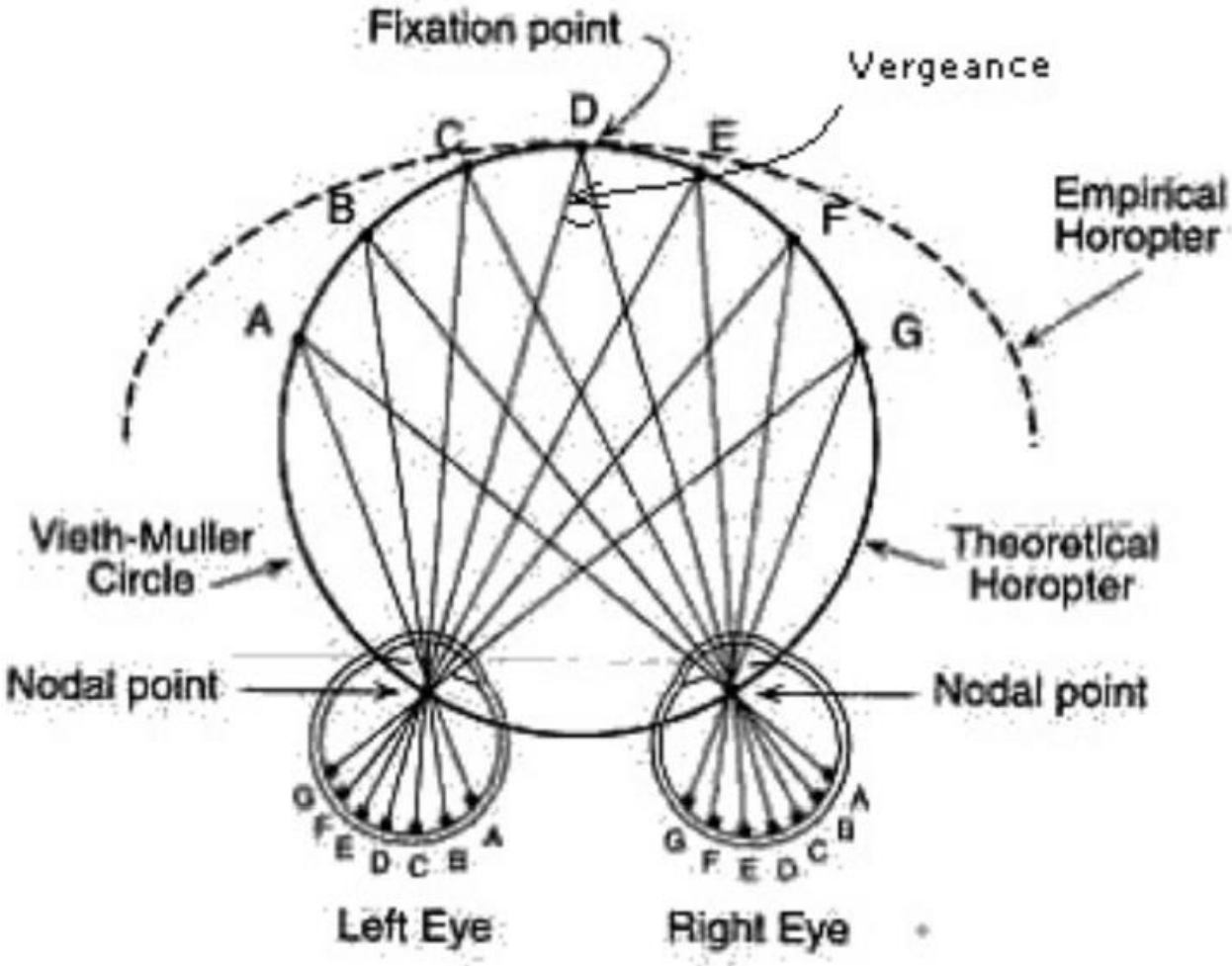


$$\mathrm{VD} = (\mathrm{IPD}/2)/\tan(\theta/2)$$

Stereopsis

- Horopter = optimal focal curve



Stereopsis

- Curved screens exploit the horopter

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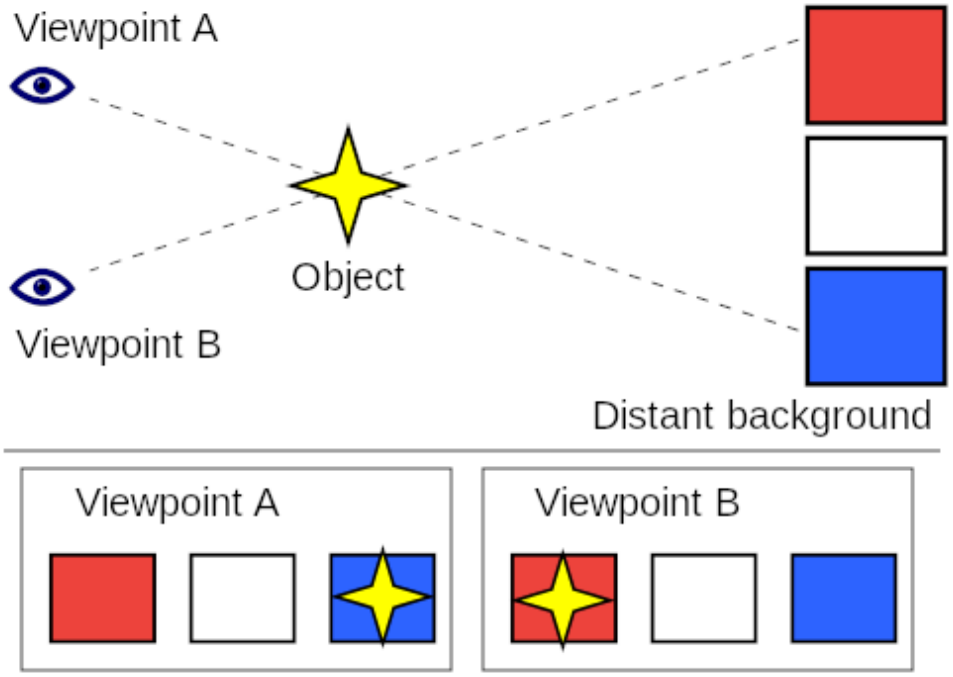
  - Accommodation

Motion Parallax

- Linear self-motion; optic flow speed depends on distance

Motion Parallax

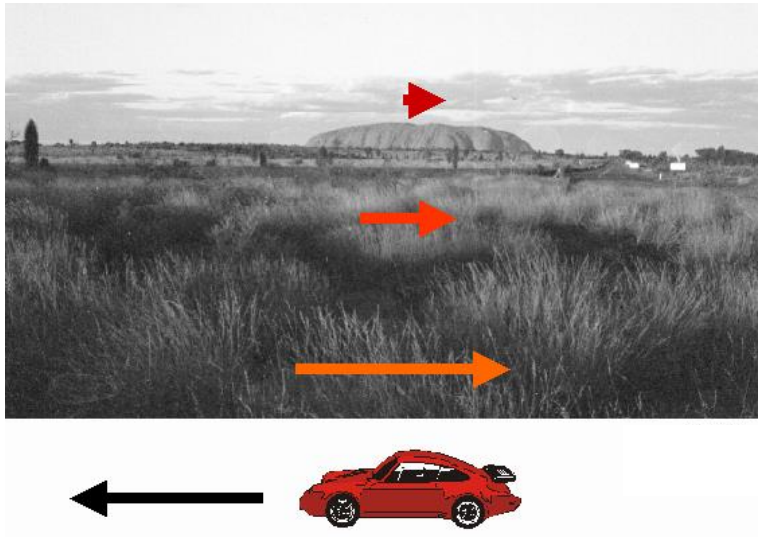
- Resembles depth from disparity
  - Depth is reconstructed from two (or more) views of the scene



Motion parallax

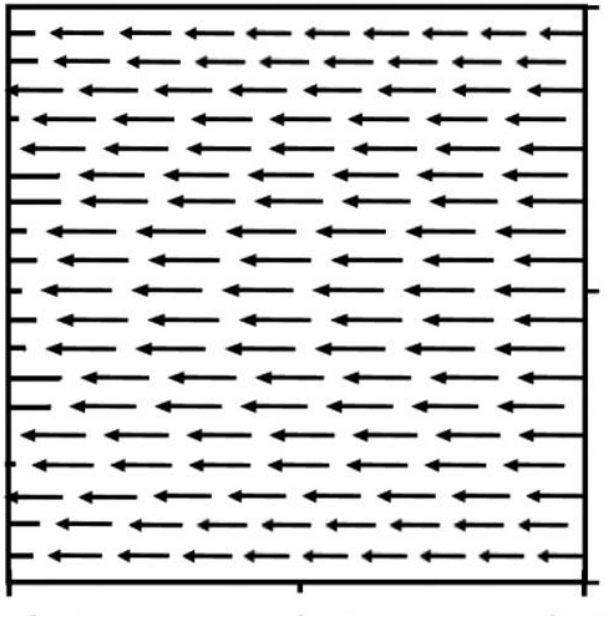
- Pursuit of point in scene adds rotational flow

Linear (self-motion)



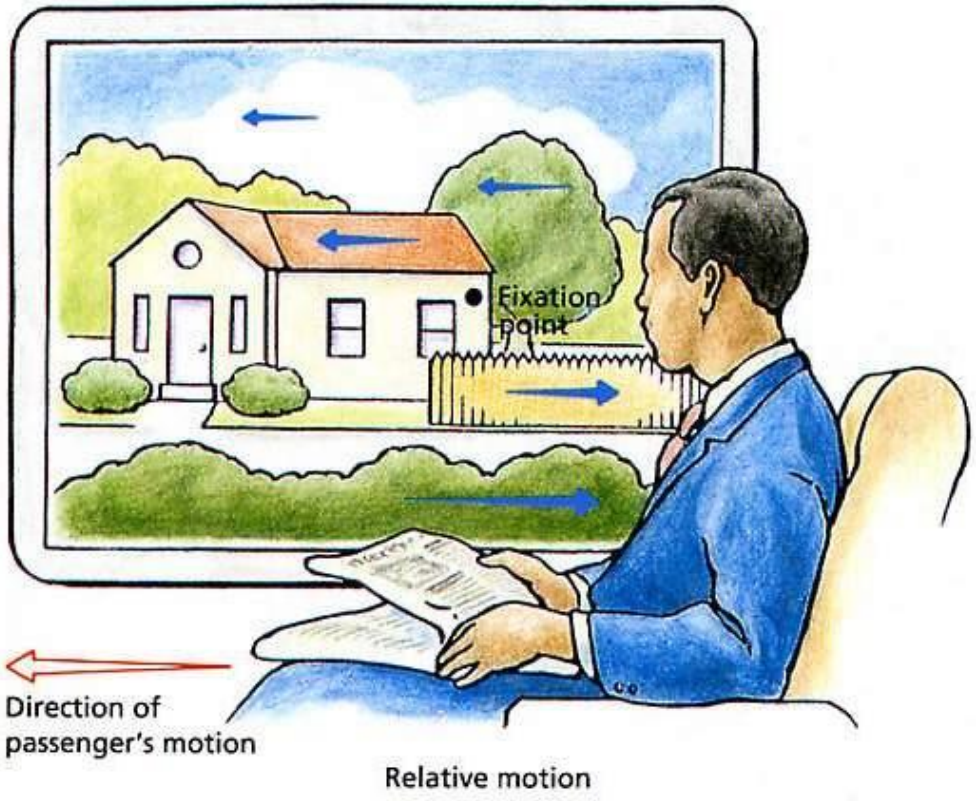
+

Angular (eye rotation)



Motion Parallax

- Classical example of motion parallax



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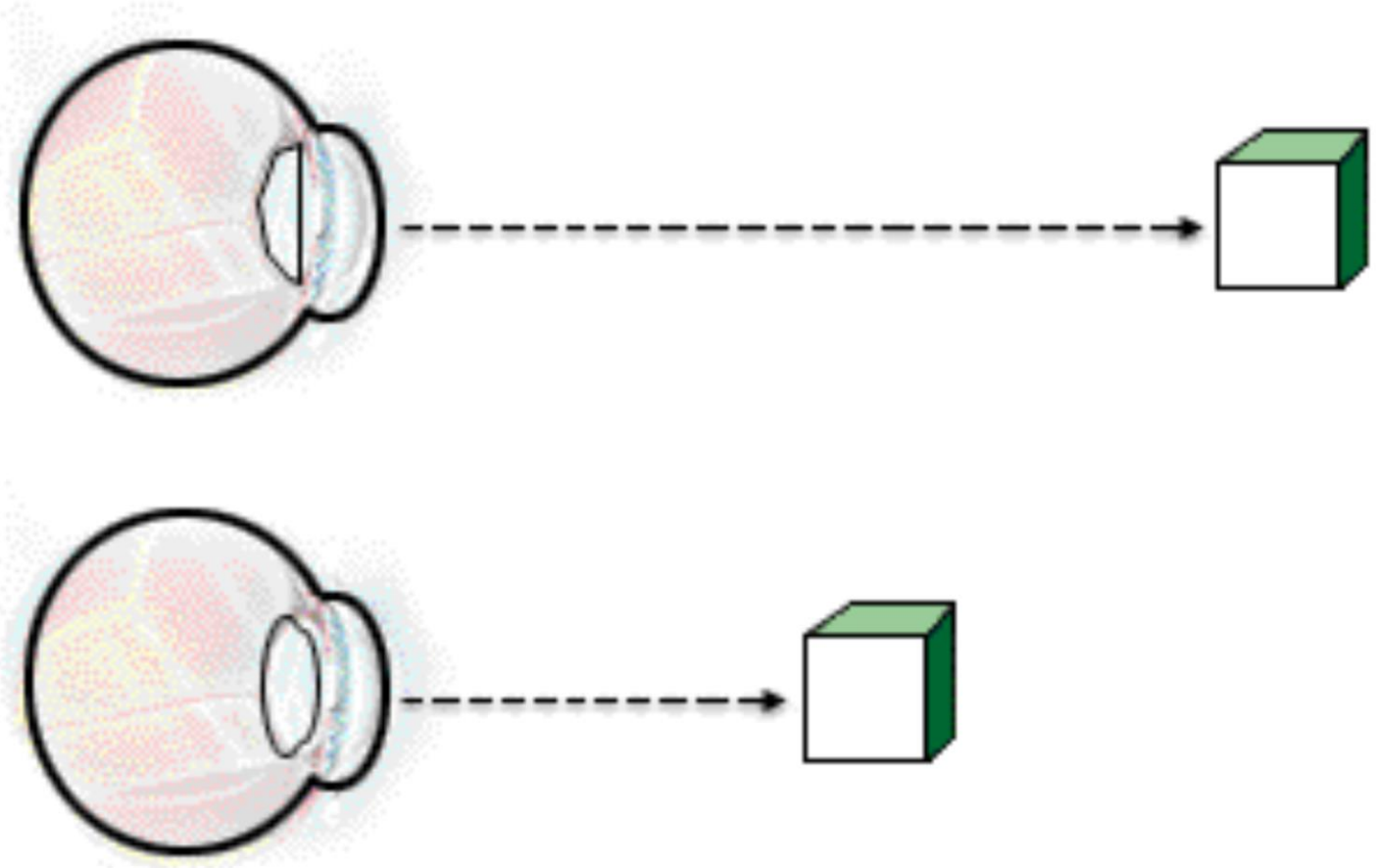
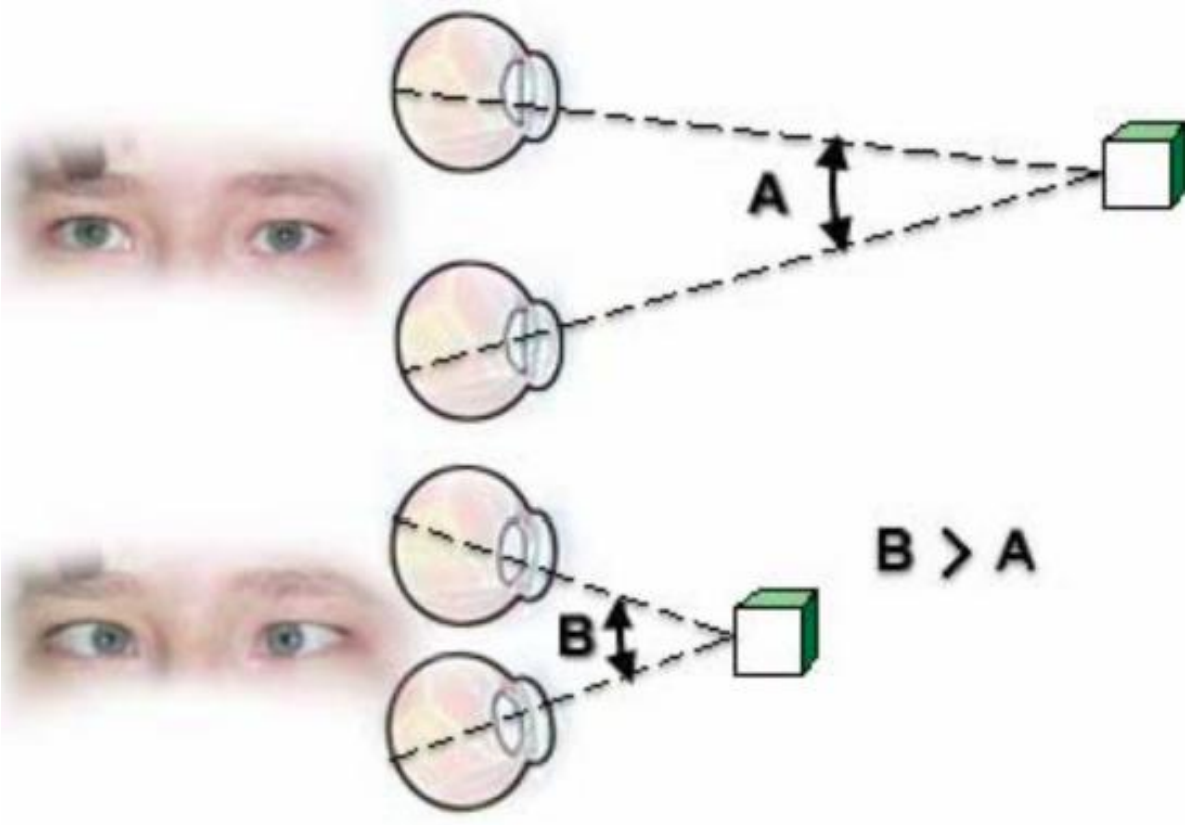
Accommodation

- Focal state of lens as cue to distance



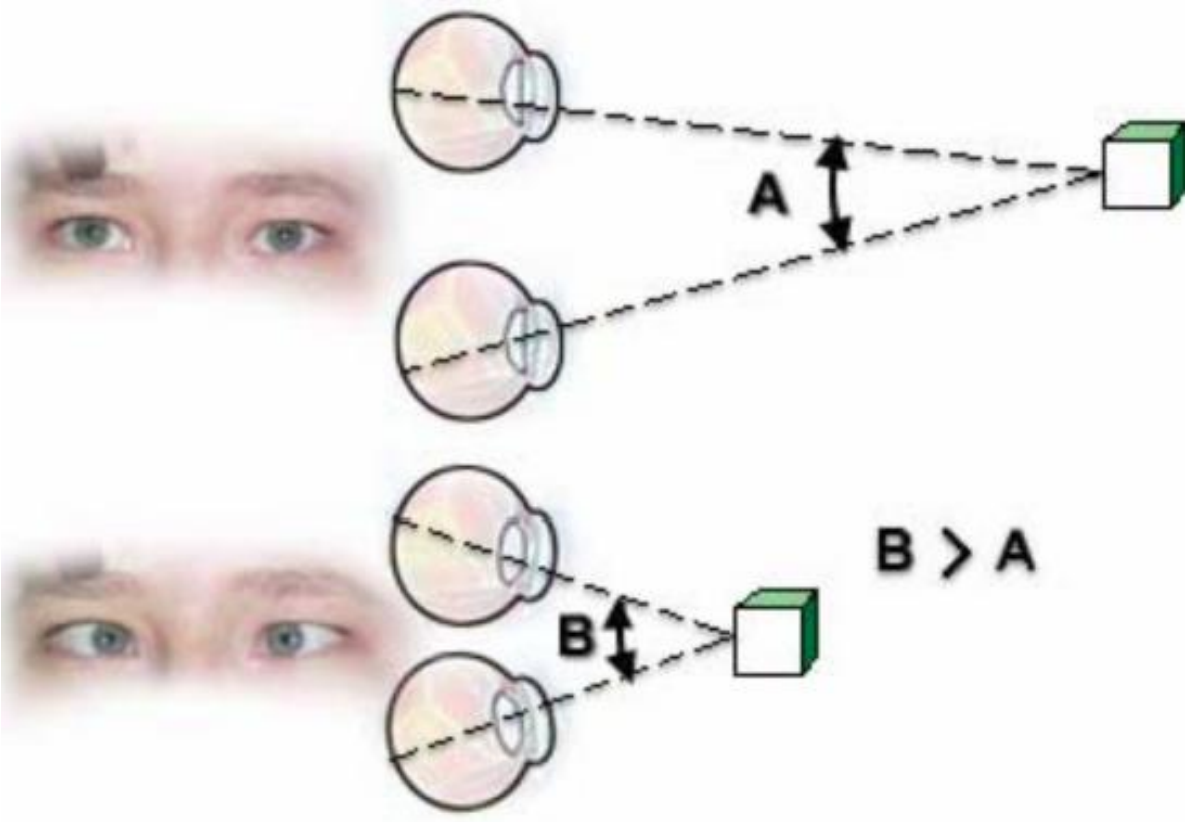
Vergence/Accommodation conflict

- In VR, no accommodation, even when the eyes are verged near



Implications for VR

- Result of vergence /accommodation conflicts?



Implications for VR

- Mismatch or conflict: hard (impossible?) to make all cues consistent

- How does the perceptual system respond to conflicts?
  - Weigh all available information depending on reliability

MORE TO COME!

Implications for VR

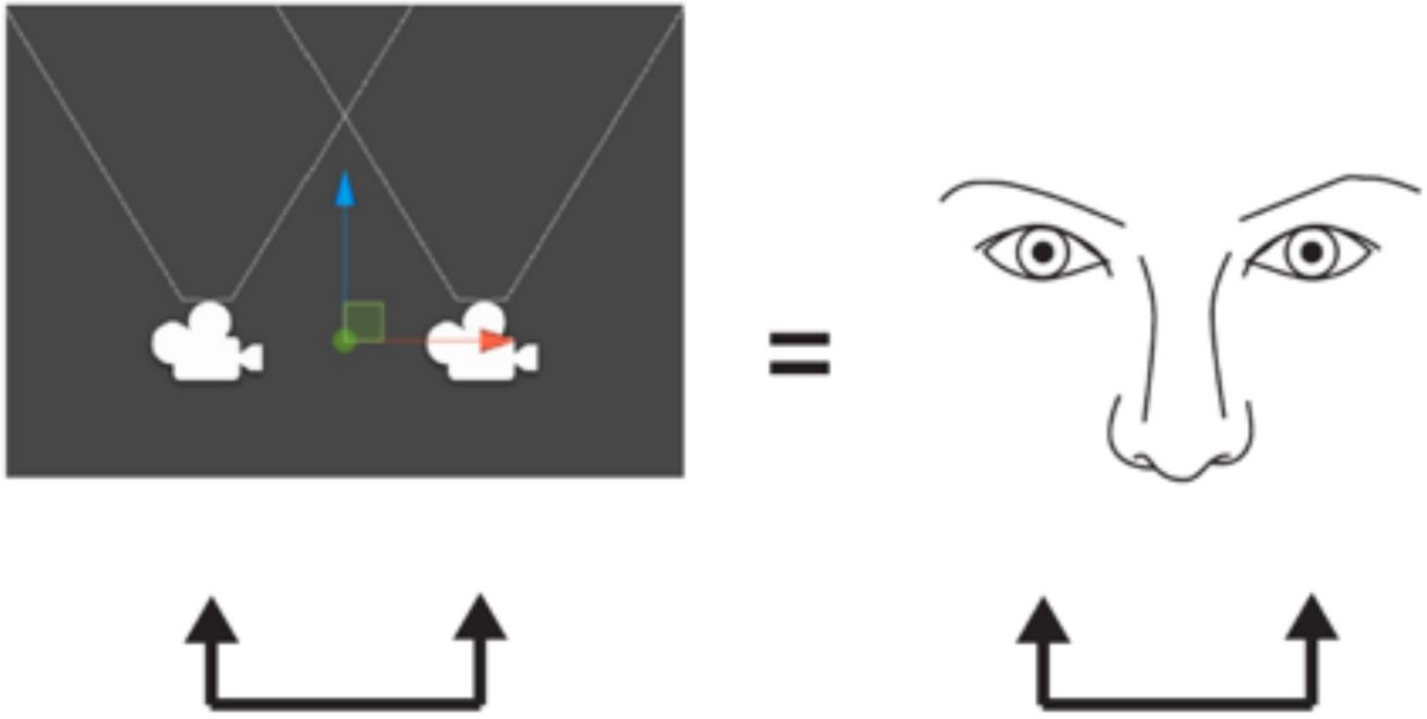
- Scaling: relatively few cues to absolute size / distance
  - Familiar size
  - Vergence angle and IPD
  - Accommodation
  - Motion parallax
- This can lead to unintended scaling in VR

Implications for VR

- Size / distance interactions (Ames room)

Implications for VR

- Result of improper interpupilary distance (IPD)?



Stereopsis

- Scaling (viewing distance; VD) depends on interpupilary distance (IPD)