Chapter 6: Space & Depth Perception

Lec 11

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normal trichromat
protanope
deuteranope
tritanope
monochromat
scotopic light levels
Color Vision in Animals

• most mammals (dogs, cats, horses): dichromats
• old world primates (including us): trichromats
• marine mammals: monochromats
• bees: trichromats (but lack “L” cone; ultraviolet instead)
• some birds, reptiles & amphibians: tetrachromats!
Color vision doesn’t work at low light levels!
Two Regimes of Light Sensitivity

- **Photopic**: cones active, rods “saturated”
  - Sunlight and bright indoor lighting

- **Scotopic**: rod vision, too dim to stimulate cones
  - Moonlight and extremely dim indoor lighting
Other (unexplained) color phenomenon:

• watercolor illusion
• neon color spreading
• motion-induced color: *Benham’s top*
Watercolor illusion
Watercolor illusion
Watercolor illusion
Neon Color-Spreading
Neon Color-Spreading
Neon Color-Spreading
Neon Color-Spreading
Benham’s top:

motion-induced color perception

http://www.michaelbach.de/ot/col_benham/index.html

• not well-understood; believed to arise from different color-opponent retinal ganglion cells having different temporal latencies.

• the flickering pattern stimulates the different color channels differently (although this is admittedly a crude theory)
Summary: color vision

- trichromacy: 3-dimensional color vision (vs. hyper-spectral cameras!)
- metamers
- color-matching experiment
- color space (RGB, HSB)
- non-spectral hues
- opponent channels, negatives & after-images
- color-opponent channels
- surface reflectance functions
- color constancy
- photopic / scotopic light levels
- additive / subtractive color mixing
- color blindness
**Depth Perception**: figuring out how far away things are

**Problem**: fundamental ambiguity between size and distance.
**Depth Perception**: figuring out how far away things are

**Problem**: fundamental ambiguity between size and distance.

- Retinal signal is the same in both cases
- Have to use a variety of “cues” to decide distance to things
PRINCETON, NJ—According to a groundbreaking new study published Thursday in *The Journal Of Natural And Applied Sciences*, people who are far away from you are actually not, as once thought, physically smaller than you.

The five-year study, conducted by researchers at Princeton University, has shattered traditionally accepted theories that people standing some distance away from you are very small, and people close-by are very big.

http://www.theonion.com/articles/study-people-far-away-from-you-not-actually-smaller,33594/?ref=auto
Moon illusion: moon looks bigger at horizon than at its zenith

One explanation:

- moon subtends same visual angle at horizon as at zenith
  (0.52 deg = a thumb’s width an arm’s length)
- if sky overhead perceived as being closer than sky at horizon, you’d infer that the moon overhead must be smaller
Motivating questions:

1. Why do we have two eyes?

2. How does the brain combine information from the two eyes to get a percept of depth?

3. How can information from just one eye provide a percept of depth?
Why have two eyes?

1. **Binocular summation**: pool twice as much light.
   - (Eye chart is easier to read with both eyes than with one, for example)

2. **Increase field of view** (prey, more than predators)

(a) Rabbit
   - 360 deg vision!

(b) Human
   - 190 deg total
   - 110 deg binocular
Why have two eyes?

1. **Binocular summation**: pool twice as much light.
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2. **Increase field of view** (prey, more than predators)

   "This explains why it is so hard to sneak up on a rabbit."

360 deg vision!
Why have two eyes?

1. **Binocular summation**: pool twice as much light.
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2. **Increase field of view** (prey, more than predators)

3. **Depth perception**: can tell how far away things are by comparing the images captured by two eyes
But first…

• **Monocular depth cue:** cue that is available even when the world is viewed with one eye alone

Surprisingly, you can get a lot of info about depth from a single eye!
Occlusion: one object obstructs the view of part of another object

- cue to relative depth order
- non-metrical depth cue - provides order information only, no measure of distance in depth
**Occlusion:** one object obstructs the view of part of another object

Could be accidental view of this

More likely scene
Relative Size

Metrical depth cue:
A depth cue that provides quantitative information about distance in the third dimension

If all beads are all the same size, then a bead twice as small is twice as far away
Depth from Shadows
Depth from Shadows
Texture Gradient
Size, Texture Gradient, & Height in Plane
Size & Texture = less influential if not paired with Height in Plane
Linear perspective

- parallel lines converge if moving away in depth
- this is due to *perspective projection*
Medieval (pre-renaissance) art
• parallel lines in a single depth plane remain parallel
• other parallel lines converge as they recede in distance
impossible figures: rely on rules of linear perspective
(provide local information about depth that is globally inconsistent)
Hans Holbein: The Ambassadors (1533)
Hans Holbein, *The Ambassadors* (1533)

“Anamorphosis is a distorted projection or perspective requiring the viewer to use special devices or occupy a specific vantage point to reconstitute the image.”
same idea: use rules of linear perspective to create images that look 3D only from a particular vantage point (i.e., an “accidental” one)
modern day anamorphic art
modern day anamorphic art

István Orosz. “Mirror Anamorphosis”
Motion Parallax

• Nearby objects move by more quickly than far away objects
Depth cues from motion parallax with wii-mote

Head Tracking for Desktop Virtual Reality Displays using the Wii Remote

Johnny Chung Lee
Human-Computer Interaction Institute
Carnegie Mellon University

http://www.youtube.com/watch?v=Jd3-eiid-Uw
Accommodation - “depth from focus”

- Lens needs more accommodation to focus nearby objects
- Blur: cue that an object is in a different depth plane
Predatory behavior

chameleon

Harkness 1977

(+) lens (-) lens