Human Visual System

Introduction to Computer Vision
CSE 152
Lecture 3

Announcements

http://cseweb.ucsd.edu/classes/sp15/cse152-a/
• Piazza
• Instructor office hours today
• Wait list
  – We’re working to get a larger room.
  – But, if you decide that you’re not going to take the class, please drop it to make room for others.

Kepler

Kepler, 1604
Eye as an optical instrument
Image is inverted on retina
First such experiment by Scheiner, 1625

Ways to study human vision

1. Physiological
2. Phenomenological/Psychophysical
3. Cellular recordings
4. Functional MRI
5. Computational modeling

Physiological level
Psychophysical Testing of Subjects

Example:
Show gratings w/ different spatial frequencies

Gradients/Motion

Perceptual Organization

Occlusion provides a different organization

Perceptual Organization

Ways to study human vision
1. Physiologically
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Single Cell Recordings

fMRI

Activation in the right fusiform gyrus. [Tarr, Cheng 2003]

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Computational Modeling

What is being computed and why?

Structure of the eye

The range of lighting

- Direct sun: 100,000 lux
- Sunny day: 50,000 lux
- Cloudy day: 5,000 lux
- Office: 400 lux
- Home lighting: 10 lux
- Street lamps: 1 lux
- Full moon: 0.1 lux
- Quarter moon: 0.01 lux
- Clear moonless night: 0.001 lux
- Cloudy moonless night: 0.0001 lux

1 lux = 1 lumens/m²
Rods and cones

Cone distribution

Three types of cones: R,G,B

Response of k'th cone: \( \rho_k(\lambda)E(\lambda)d\lambda \)

There are three types of cones:
- S: Short wave lengths (Blue)
- M: Mid wave lengths (Green)
- L: Long wave lengths (Red)

- Three attributes to a color
- Three numbers to describe a color

Retina edge on

Other Eyes
Trilobite Visual System

- Most ancient known visual system.
- Compound eye with single crystal for each lens.

Electron Micrograph of Holochroal eye

Good trilobite eye info at: http://www.aloha.net/~smgon/eyes.htm

Scallop eyes

- Hundreds of primitives eyes, mirror in back
- Changes in light and motion and very rough images are registered on the retinas of the mollusk.
- Nice material at: http://soma.npa.uiuc.edu/courses/bio303/Ch1b.html

Stomatopod eyes

- Dumb bell shaped, compound eyes (next slide)
- Stereo vision with just one eye;
- Each eye is up on a stalk, with a wide range of motion;
- Stomatopods have up to 16 visual pigments stomatopods
- can see ultra-violet and infra-red light
- some can see polarized light.
- See http://www.ucmp.berkeley.edu/aquarius/

Mantis Shrimp

Trinocular vision

Visual Pathways

Single Cell Recordings
Fixate at center
What color are the dots

Shading Cues

Subjective Contours
Kanizsa’s Triangle

Which square is darker?
Which square is darker?

Global vs. Local information: Fraser’s Spiral

Context

Context: Whose faces do you see?

Who is taller? Who is taller?
A picture of a man

In this shot, what is his facial expression?

In this shot, what is his facial expression?

Thatcher illusion

Hidden Human Face

Additional Pictures

Parallel Lines