Human Visual System

Computer Vision I
CSE 252a
Lecture 2

Announcements

• Assignment 0: “Getting Started with Matlab” is posted to the web page, due next Tuesday.

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. Physiologically
2. Phenomenological/Psychophysical
3. Cellular recordings
4. Functional MRI
5. Computational modelling

Physiological level

What does this do?

Can we readily understand whole from understanding pieces?
Ways to study human vision

1. Physiologically
2. Phenomenological/Psychophysical
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Psychophysical Testing of Subjects

Example:
Show gratings with different spatial frequencies

Gradients/Motion

Perceptual Organization

Occlusion provides a different organization

Perceptual Organization
Ways to study human vision

1. Physiologically
2. Phenomenological/Psychophysical
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Single Cell Recordings

fMRI

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

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

**Rods and cones**

- Three types of cones:
  - S: Short wavelength (Blue)
  - M: Mid wavelength (Green)
  - L: Long wavelength (Red)

- Response of k'th cone: \( \int p_k(\lambda)E(\lambda)d\lambda \)

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

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

**Distribution of Rods & Cones**

3.3 THE DISTRIBUTION OF ROD AND CONE PHOTORECEPTORS across the human retina. (A) Degrees of visual angle relative to the position of the fovea for the left eye; the position of the blind spot is also shown. (B) The cone receptors are concentrated in the fovea. The rod photoreceptors are absent from the fovea and reach their highest density between 10 and 20 degrees peripheral to the fovea. No photoreceptors are present in the blind spot.

**Retina edge on**

- Three types of cones:
  - S: Short wavelengths (Blue)
  - M: Mid wavelengths (Green)
  - L: Long wavelengths (Red)

- Three attributes to a color:
  - Three numbers to describe a color
Retinal Neuron

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/Ch11b.html

Stomatopod eyes

- Dumb bell shaped, compound eyes
- 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 also see ultra-violet and infra-red light, and some can even see polarized light.
- See http://www.ucmp.berkeley.edu/aquarius/

Visual Pathways
Single Cell Recordings

What: Recognition, Object representation
Where: Location & Motion, control

Fixate at center
What color are the dots

CUES

Subjective Contours
Kanizsa’s Triangle

Shading Cues
Which square is darker?

Fraser’s Spiral

Context

Who is taller? Which man is taller?
Context: Whose faces do you see?

A picture of a man

In this shot, what is his facial expression?

In this shot, what is his facial expression?

Hidden Human Face