Human Visual System

Introduction to Computer Vision
CSE 152
Lecture 2

Announcements
- Assignment 0: due Thursday 4/12
- Office Hour: Tuesdays 1:00-2:00
- Read Trucco & Verri: pp. 15-40

Pythagoras

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

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Psychophysical Testing of Subjects

Example:
Show gratings w/ different spatial frequencies

Gradients/Motion

Perceptual Organization

Occlusion provides a different organization
Perceptual Organization

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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

Rods and cones

Rods & Cones

Three types of cones: R,G,B

Distribution of Rods & Cones

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

Three types of cones: R,G,B

Response of k'th cone = \[ \int p(\lambda)E(\lambda)d\lambda \]

Distribution of Rods & Cones

3.1 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

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/
Mantis Shrimp

Visual Pathways

Single Cell Recordings

Fixate at center
What color are the dots
Subjective Contours
Kanizsa’s Triangle

Shading Cues

Which square is darker?

Which square is darker?

Fraser’s Spiral