

Human Visual System

Introduction to Computer Vision

CSE 152

Lecture 18

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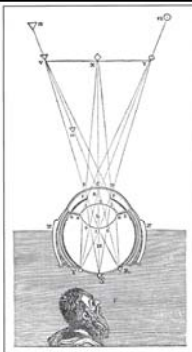
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Announcements

- Homework 5 is due Sat, Jun 10, 11:59 PM
- Take home final* is due Fri, Jun 16, 9:59 PM
 - Final will be posted on Piazza
- Please complete TA and course evaluations
- Reading:
 - Section 1.1.4: The Human Eye

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Kepler

Kepler, 1604

Eye as an optical instrument

Image is inverted on retina

First such experiment by Scheiner, 1625

Figure 2.3 Image formation on the retina, according to Descartes. Descartes removed the eye of an ox, swapped its back to make it transparent, and then observed it from a darkened room "not perhaps without wonder and pleasure" the inverted image of a worm (see [Pavlov 1907]). Such an experiment was performed originally by Scheiner, first with the eyes of sheep and cows, and then, in 1625, with a human eye; the formation of an inverted retinal image was proposed by Kepler in 1604 (see [Pavlov 1907]). (From Descartes's *La Philosophie*, 1637.)

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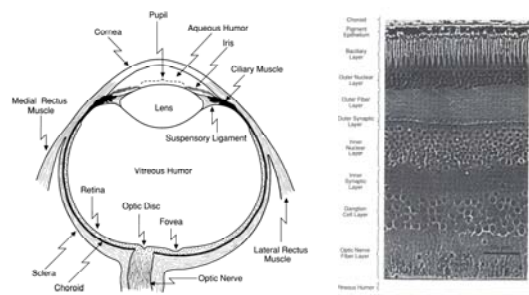
Ways to study human vision

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

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Physiological level



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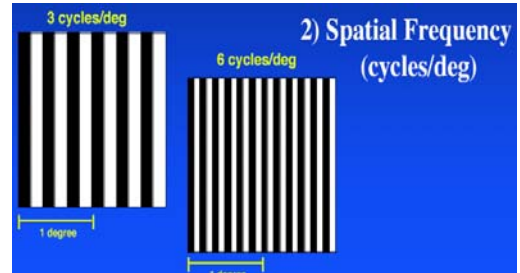
Psychophysical Testing of Subjects



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Example:
Show gratings with different spatial frequencies



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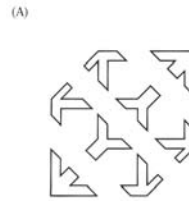
Gradients/Motion



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Perceptual Organization



Occlusion provides a different organization

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Perceptual Organization



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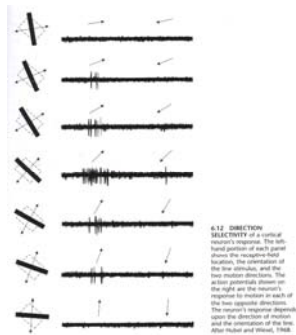
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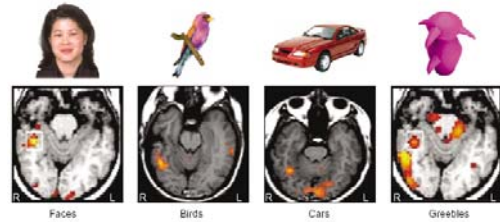
Single Cell Recordings



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fMRI



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

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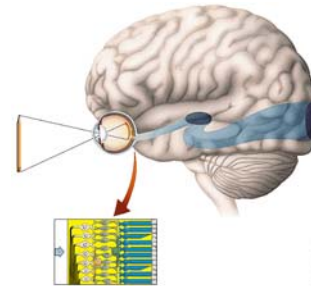
Ways to study human vision

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Computational Modeling

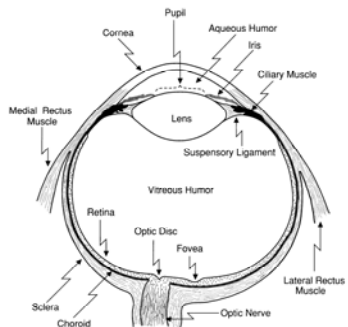


What is being computed and why?

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Structure of the eye



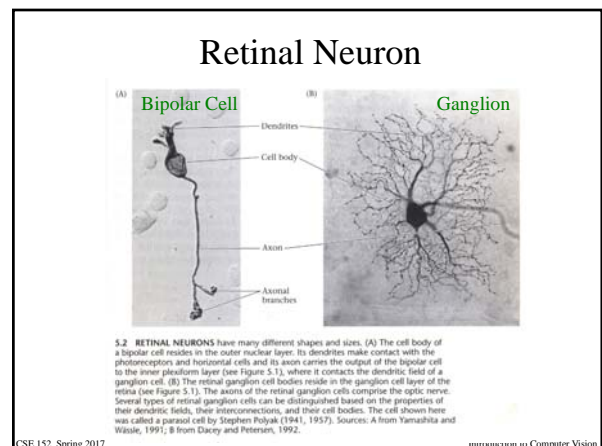
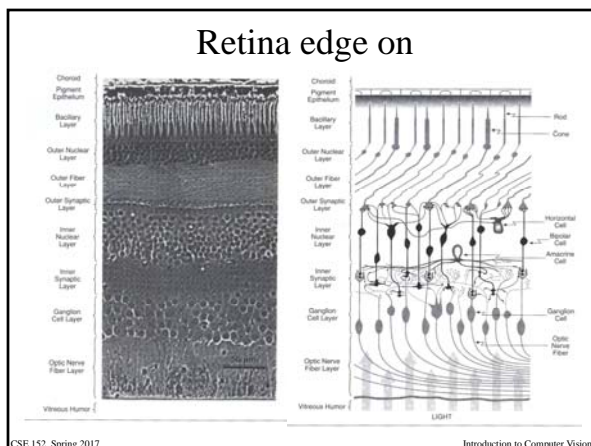
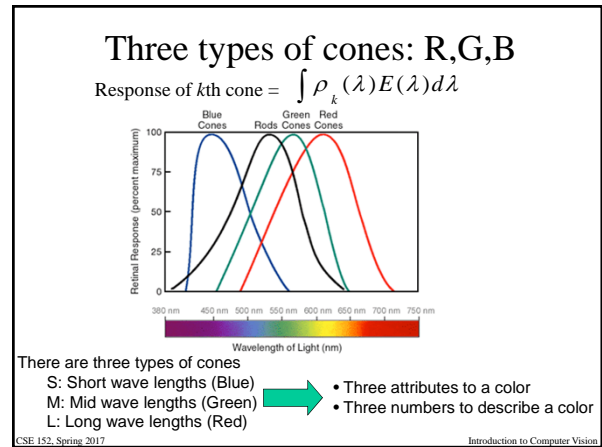
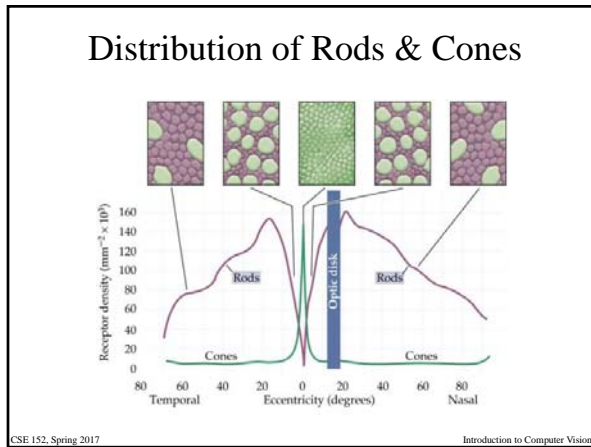
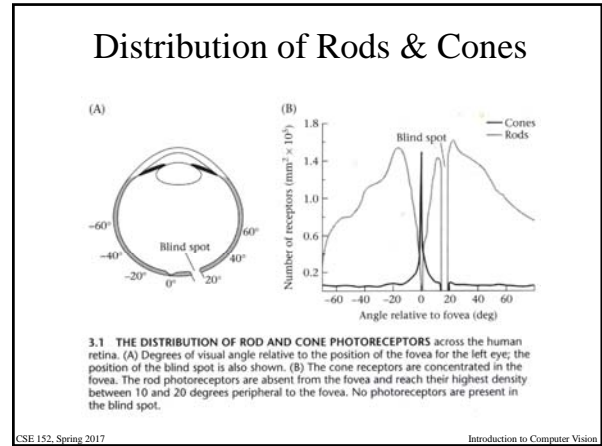
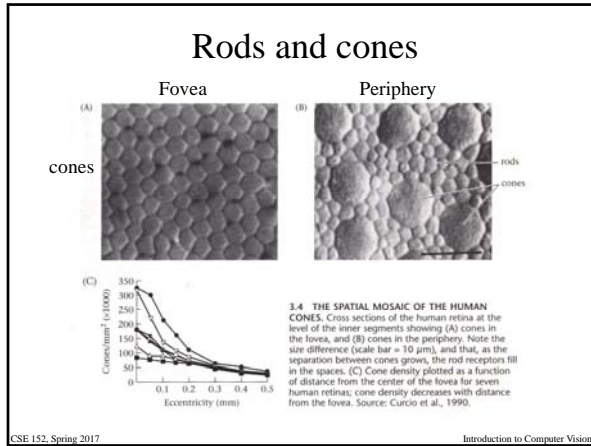
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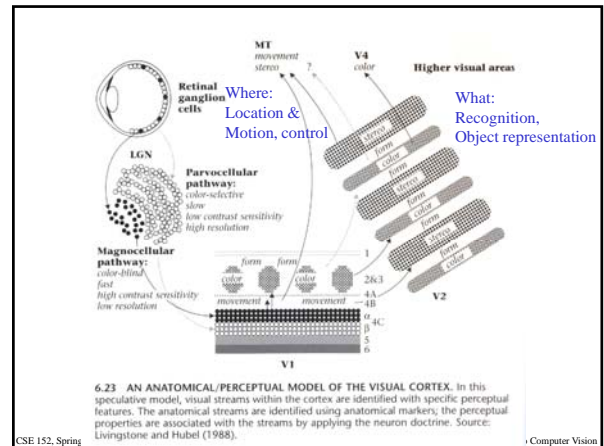
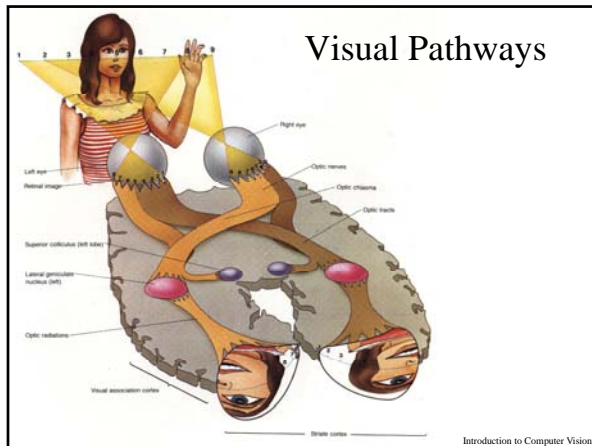
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The range of lighting

	Direct sun	100'000 Lux	Electronic imagers Total lighting range
	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 lumen/m ²	

C






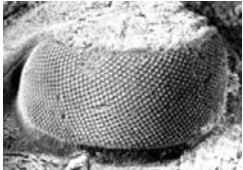
Other Eyes

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Trilobite Visual System

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

Electron Micrograph of Holochroal eye







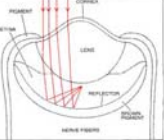
Good trilobite eye info at: <http://www.aloha.net/~smgon/eyes.htm>

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Scallop eyes

- Hundreds of primitive 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>







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Stomatopod eyes

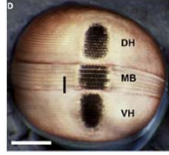
- Dumb bell shaped, compound eyes (next slide)
- Stereo vision with just one eye;
- Each eye is up on a stalk, with a wide range of motion;
- Stomatopods have up to 16 visual pigments
 - stomatopods can see ultra-violet and infra-red light
 - some can see polarized light
- See <http://www.ucmp.berkeley.edu/aquarius/>

Larva Mantis Shrimp
Adult Mantis Shrimp

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Mantis Shrimp



Trinocular vision

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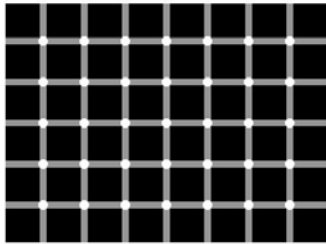
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Cues

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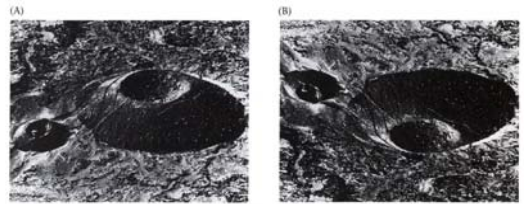
Fixate at center
What color are the dots?



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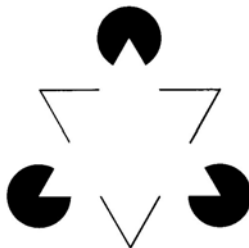
Shading Cues



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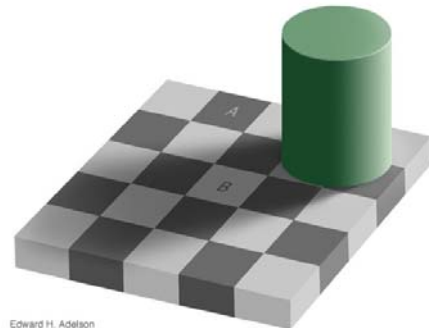
Subjective Contours
Kanizsa's Triangle



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Which square is darker?



Edward H. Adelson

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Which square is darker?

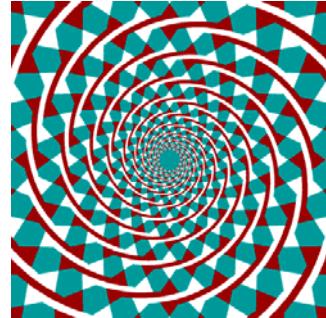


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Global vs. Local information:
Fraser's Spiral



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Context



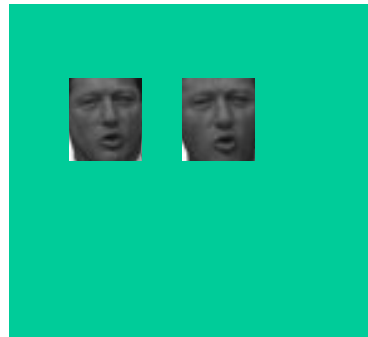
Who is taller?

Who is taller?

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Context: Whose faces do you see?



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A picture of a man



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In this shot, what is his facial expression?



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In this shot, what is his facial expression?

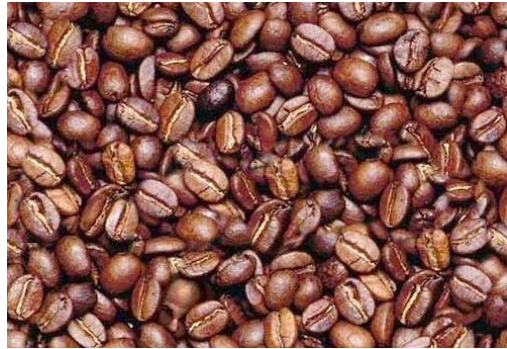


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Thatcher illusion

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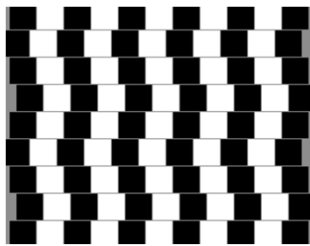
Hidden Human Face



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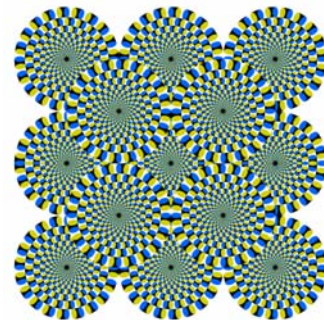
Horizontal Lines are Parallel



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Static Image



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Summary of CSE 152

- Geometric image formation
- Photometric image formation
- Photometric stereo
- Binary image processing
- Filtering
- Edges and corners
- Stereo
- Structure from motion
- Model fitting
- Optical flow and motion
- Tracking
- Recognition, detection, and classification
- Color
- Human visual system