

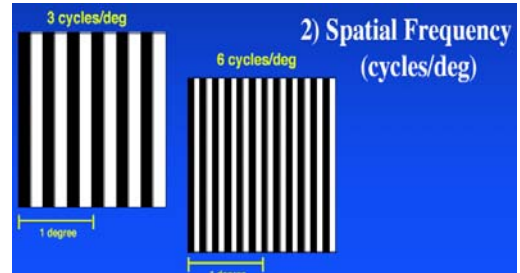
Psychophysical Testing of Subjects



CSE 152, Spring 2016

Introduction to Computer Vision

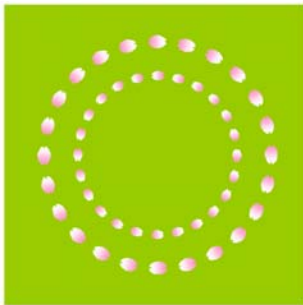
Example:
Show gratings with different spatial frequencies



CSE 152, Spring 2016

Introduction to Computer Vision

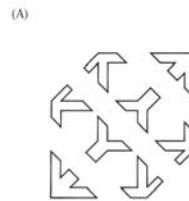
Gradients/Motion



CSE 152, Spring 2016

Introduction to Computer Vision

Perceptual Organization



Occlusion provides a different organization

CSE 152, Spring 2016

Introduction to Computer Vision

Perceptual Organization



CSE 152, Spring 2016

Introduction to Computer Vision

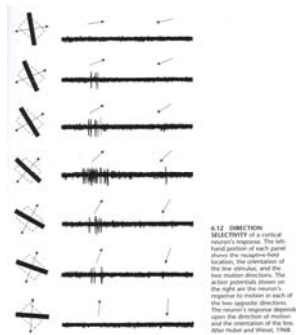
Ways to study human vision

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

CSE 152, Spring 2016

Introduction to Computer Vision

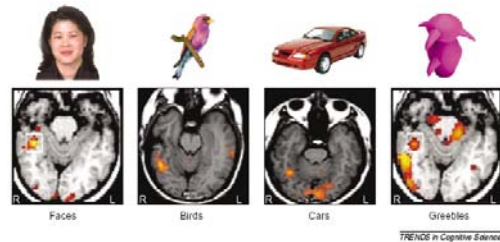
Single Cell Recordings



CSE 152, Spring 2016

Introduction to Computer Vision

fMRI



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

CSE 152, Spring 2016

Introduction to Computer Vision

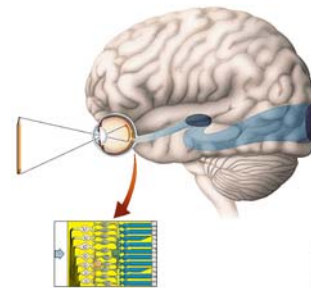
Ways to study human vision

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

CSE 152, Spring 2016

Introduction to Computer Vision

Computational Modeling

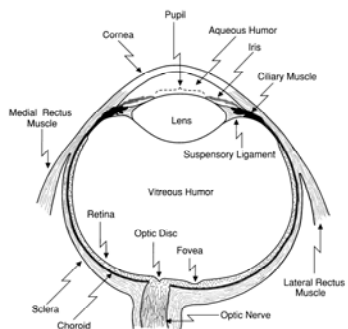


What is being computed and why?

CSE 152, Spring 2016

Introduction to Computer Vision

Structure of the eye



CSE 152, Spring 2016

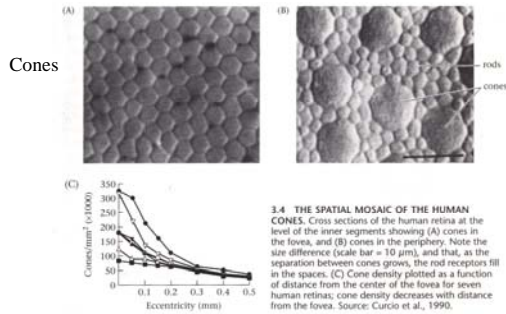
Introduction to Computer Vision

The range of lighting

	Direct sun	100'000 Lux	Total lighting range Electronic imagers
	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

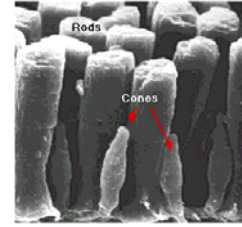
Rods and cones



CSE 152, Spring 2016

Introduction to Computer Vision

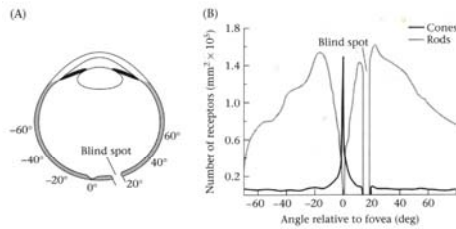
Rods and cones



CSE 152, Spring 2016

Introduction to Computer Vision

Distribution of Rods & Cones

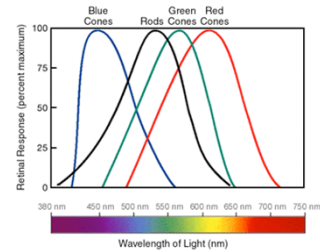


CSE 152, Spring 2016

Introduction to Computer Vision

Three types of cones: R,G,B

$$\text{Response of } k\text{th cone} = \int \rho_k(\lambda) E(\lambda) d\lambda$$



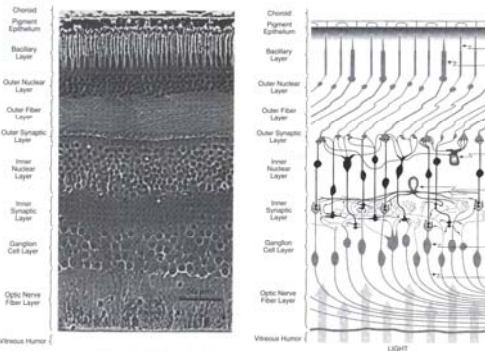
There are three types of cones

- 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

CSE 152, Spring 2016

Introduction to Computer Vision

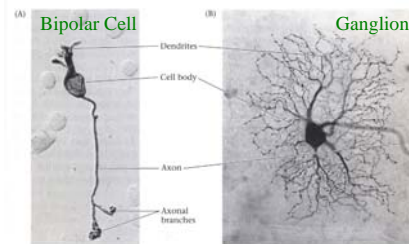
Retina edge on



CSE 152, Spring 2016

Introduction to Computer Vision

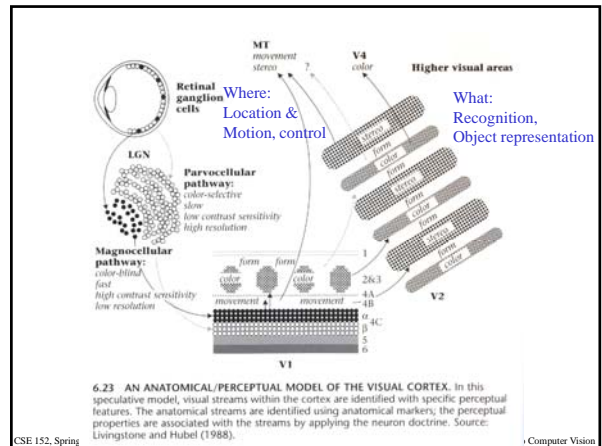
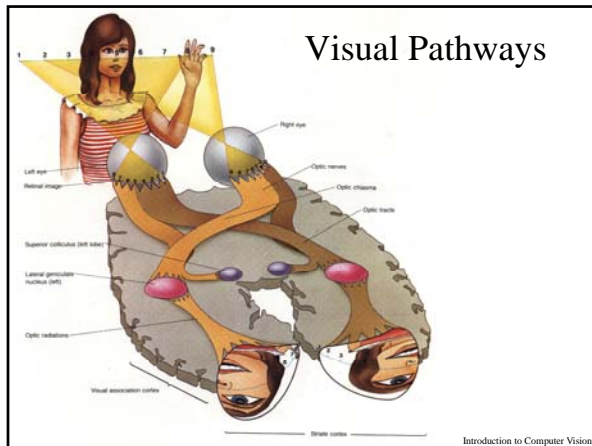
Retinal Neuron



5.2 RETINAL NEURONS have many different shapes and sizes. (A) The cell body of a bipolar cell resides in the outer nuclear layer. Its dendrites make contact with the photoreceptors and horizontal cells and its axon carries the output of the bipolar cell to the inner plexiform layer (see Figure 5.1), where it contacts the dendritic field of a ganglion cell. (B) The retinal ganglion cell bodies reside in the ganglion cell layer of the retina (see Figure 5.1). The axons of the retinal ganglion cells comprise the optic nerve. Several types of retinal ganglion cells can be distinguished based on the properties of their dendritic fields, their interconnections, and their cell bodies. The cell shown here was called a parasol cell by Stephen Polyak (1941, 1957). Sources: A from Yamashita and Wässle, 1991; B from Dacey and Petersen, 1992.

CSE 152, Spring 2016

Introduction to Computer Vision



Other Eyes

Other Eyes


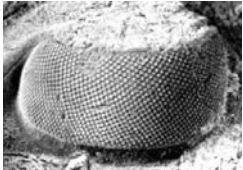
CSE 152, Spring 2016

Introduction to Computer Vision

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>


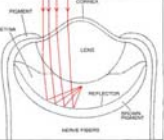
CSE 152, Spring 2016

Introduction to Computer Vision

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>







CSE 152, Spring 2016

Introduction to Computer Vision

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/>

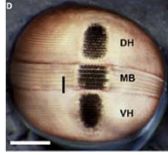




Larva Mantis Shrimp Adult Mantis Shrimp

CSE 152, Spring 2016

Introduction to Computer Vision

Mantis Shrimp



Trinocular vision

CSE 152, Spring 2016

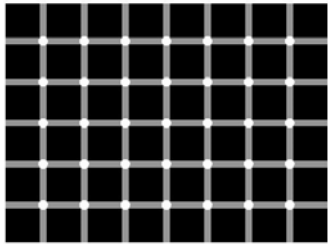
Introduction to Computer Vision

Cues

CSE 152, Spring 2016

Introduction to Computer Vision

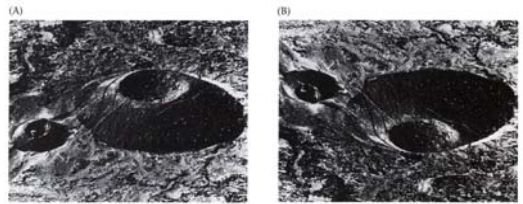
Fixate at center
What color are the dots?



CSE 152, Spring 2016

Introduction to Computer Vision

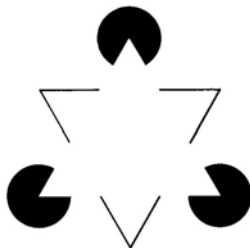
Shading Cues



CSE 152, Spring 2016

Introduction to Computer Vision

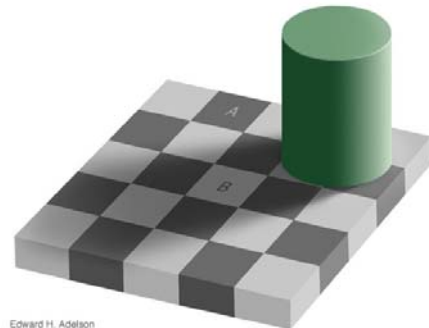
Subjective Contours
Kanizsa's Triangle



CSE 152, Spring 2016

Introduction to Computer Vision

Which square is darker?



Edward H. Adelson

CSE 152, Spring 2016

Introduction to Computer Vision

Which square is darker?

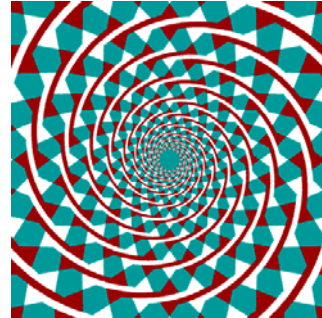


Edward H. Adelson

CSE 152, Spring 2016

Introduction to Computer Vision

Global vs. Local information:
Fraser's Spiral



CSE 152, Spring 2016

Introduction to Computer Vision



CSE 152, Spring 2016

Introduction to Computer Vision



CSE 152, Spring 2016

Introduction to Computer Vision

Context



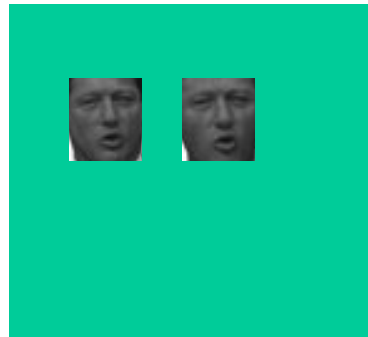
Who is taller?

Who is taller?

CSE 152, Spring 2016

Introduction to Computer Vision

Context: Whose faces do you see?



CSE 152, Spring 2016

Introduction to Computer Vision

A picture of a man



CSE 152, Spring 2016

Introduction to Computer Vision

In this shot, what is his facial expression?



CSE 152, Spring 2016

Introduction to Computer Vision

In this shot, what is his facial expression?

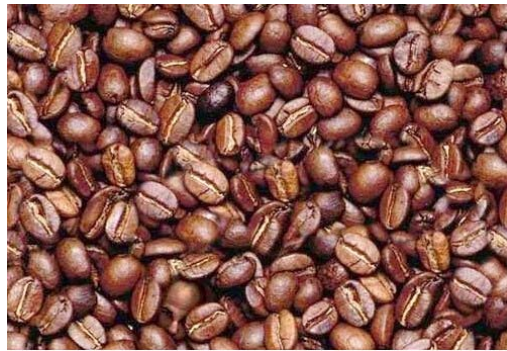


CSE 152, Spring 2016

Thatcher illusion

Introduction to Computer Vision

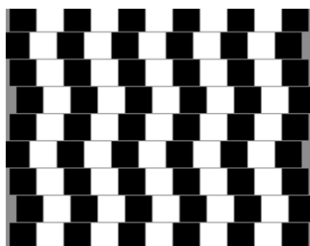
Hidden Human Face



CSE 152, Spring 2016

Introduction to Computer Vision

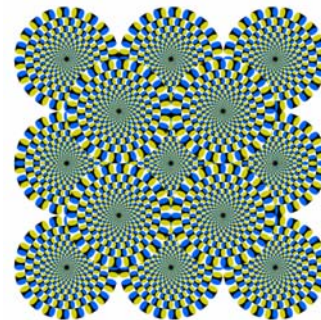
Horizontal Lines are Parallel



CSE 152, Spring 2016

Introduction to Computer Vision

Static Image



CSE 152, Spring 2016

Introduction to Computer Vision

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