CS510: Image Computation

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Class Goals

- Prepare you to do research in computer vision
  - Provide "big picture" (comparison to humans)
  - Give you experience reading papers
  - Familiarize you with SOA methods/algorithms
  - Familiarize you with open problems
  - Familiarize you with experimental methodology

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Class Project

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Class Project

- Identify objects in videos
  - Moving objects : potential actors
  - Still objects : potential related objects
- Identify actions in videos
  - E.g. walk, run, stand, pick up, dig, etc.
- Describe short videos in simple English sentences
  - S → N V [DO] [IO] [PP]
- Note: this was SOA in 2012

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Class Project (II)

- I/O (PA1)
- Attention
  - Still object attention (PA2) [DoG]
  - Moving object attention (PA3) [ViBE / MoG]
  - Tracking (PA3) [Kalman / Particle / MOSSE]
- Classification
  - Object identification (PA4) [CNN]
  - Action identification (PA5) [ANN / BoW]
- Sentence Generation (PA6)
  - Information fusion [Markov]
  - Relations [Grammars / Schemas]
- *Expertise*
  - *PCA, Manifolds (PA7)*

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Administrivia

- Workload:
  - Programming assignments (40%)
    - At least 6 (hopefully 7)
    - Roughly every two weeks
    - Large assignments – teams of 2 or 3
    - Assignments build on each other
      - A single project
  - Tests (40%)
    - 3 tests
    - All in-class
    - No "exam"

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Administrivia (II)

- Readings
  - Ungraded
  - Emphasized on tests
  - Make connections to project presentations
- Project presentations (20%)
  - Details may vary by team (size, etc.)
  - Relate projects to readings, class lectures
- Class web site: http://www.cs.colostate.edu/~cs510
  - Progress page has lectures & reading assignments
  - Assignments page has assignments
  - No Canvas page for this class

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Misconceptions about Vision

- Vision is passive
  - Bad metaphor: video recorder
  - Better metaphor: blind-folded touch
- Vision is 3D
  - Bad metaphor: 3D sensor
    - E.g. Kinect, ladar range finder, etc.
  - Better metaphor: theater with backdrop

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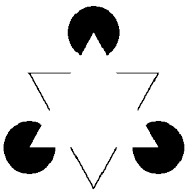
Illusions

Kanizsa Triangle



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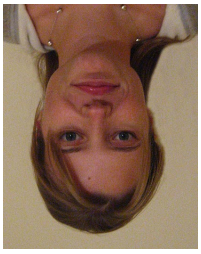
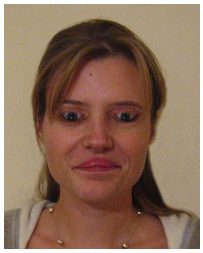
Illusions





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Why Illusions?

- Collectively, what do these illusions tell us?
  - Vision (sensing) is active
  - We select what we attend to
  - We construct percepts from what we sense
- What is the lesson for artificial vision?
  - Must actively seek information
  - Must be "like people"

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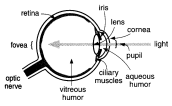
Input: The Eye(s)

Start at the beginning:

- Lens focuses light
- Iris serves as aperture
- Retina contains receptors
- Optic nerve transmits to brain



S. Palmer. *Vision Science*. P. 27

Gaze, lens, iris are controlled by muscles under the control of the brain

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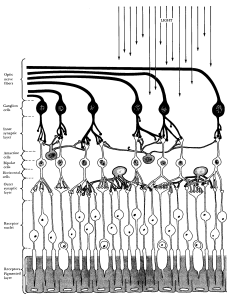
Retina as Processor

S. Palmer. *Vision Science*. P. 30



- Five cell types:
  - receptor (rod/cones)
    Species dependent
  - horizontal
  - bipolar cells
  - amacrine cells
  - ganglion cells
- Its inside out!
- Blind spot where optic nerve passes through retina

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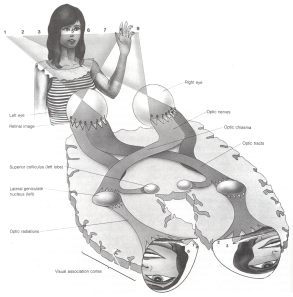
Fields of View & Stereo

- Right hemisphere receives the left visual field from both eyes
  - And vice-versa
  - Splitting the field of view supports disparity computations
- High resolution in fovea, lower elsewhere
  - Fovea is ±2° (thumbnai at arms length)



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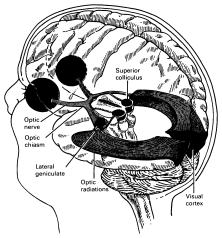
Projections (LGN & S.C.)



S. Palmer. *Vision Science*. P. 25.

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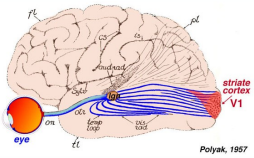
Primary Visual Cortex (V1)

- First cortical visual area
  - Columnar (like all cortex)
- Retinotopically mapped
- Ocular dominance columns
- Edges (Gabor filters), color, disparity & motion maps
- Connects to other retinotopic areas (V2, V3, MT)



http://webvision.med.utah.edu/imageswv/capas-cortex.jpg

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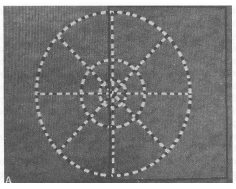
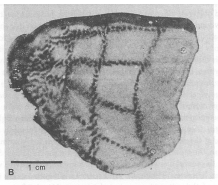
Tootell, et al. 1982.

Proof of Retinotopic Mapping



Pattern flashed (like a strobe) in front of monkey injected with sugar dye



Left primary visual cortex of the same monkey

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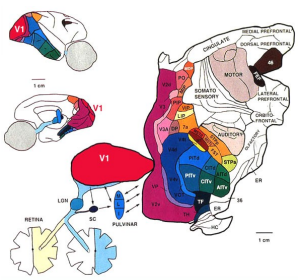
V1 Connections

From Van Essen 1992. Image can be found at http://webvision.med.utah.edu/imageswv/Visual-Cortex1.jpg



V1 is the starting point of cortical visual processing.

Dorsal projections lead to somatosensory and motor control areas

Ventral projections lead toward associative memories

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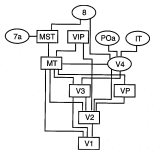
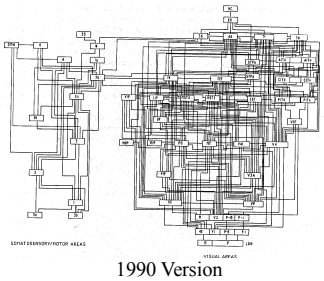
Anatomical Maps of Visual Cortex



1983 Version



1990 Version

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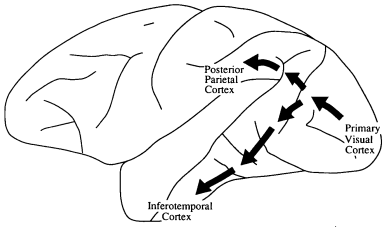
Visualizing Two Subsystems



D. Milner & M. Goodale, *The Visual Brain in Action*, p. 22

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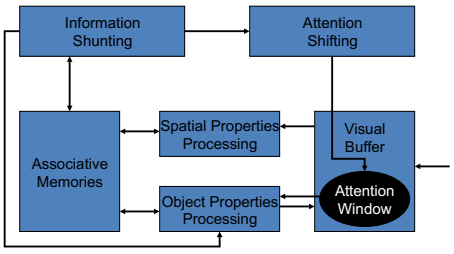
A Model of Human Vision



S. Kosslyn, 2006

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(The same model of) Human Vision