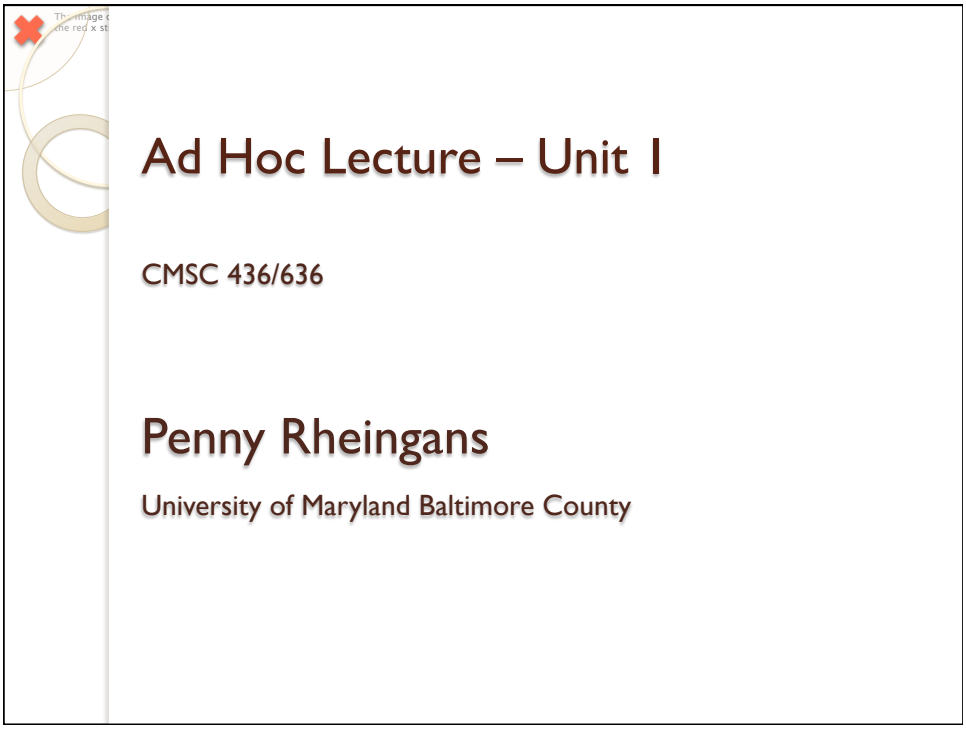

Ad Hoc Lecture – Unit 1

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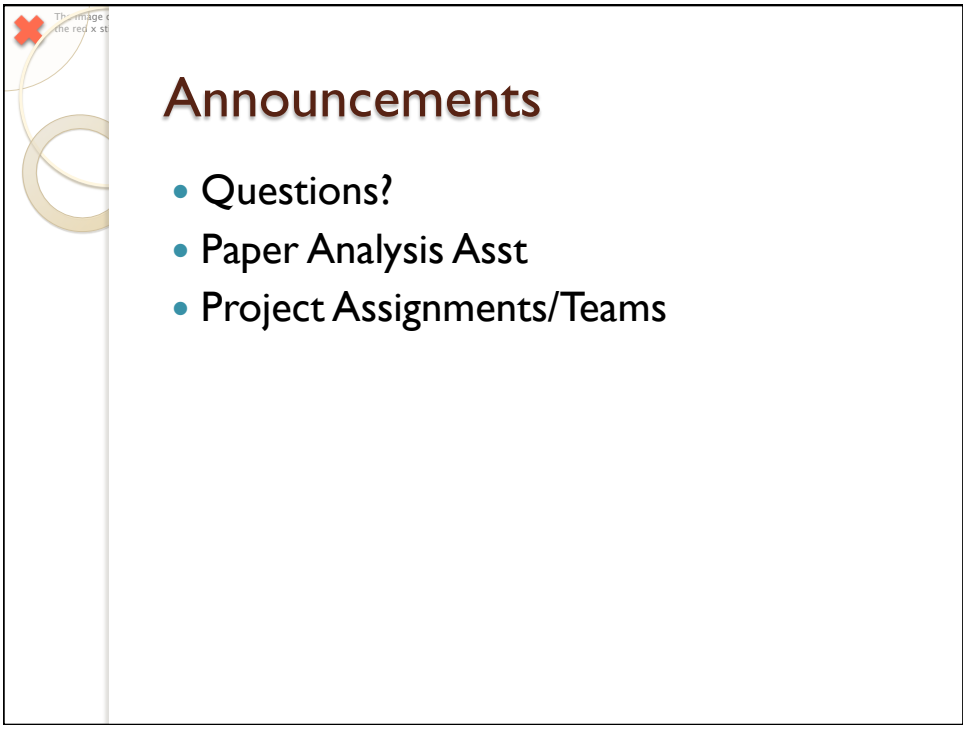
University of Maryland Baltimore County



Announcements

- Questions?
- Paper Analysis Asst
- Project Assignments/Teams

Spatial Vision

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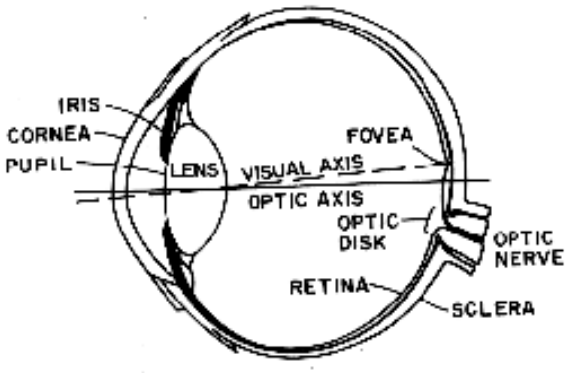
Light

- Visible range: 390-700nm
- Luminance has a large dynamic range:
  - 0.00003 -- Moonless overcast night sky
  - 30 -- Sky on overcast day
  - 3000 -- Sky on clear day
  - 16,000 -- Snowy ground in full sunlight
- Actual colors result from spectral curves
  - dominant wavelength, hue
  - brightness, lightness
  - purity, saturation

Physiology: Eye

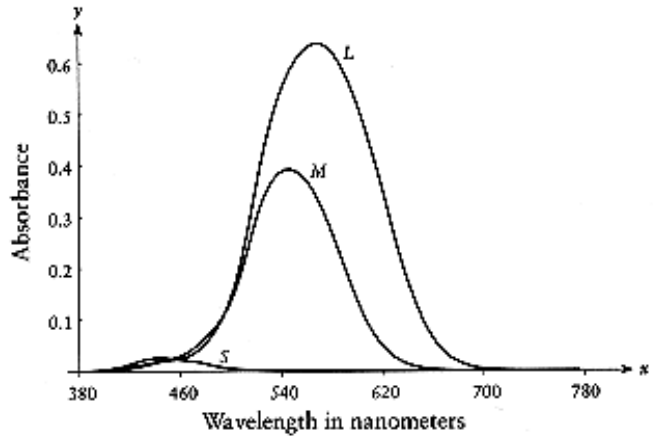
- Cornea
- Iris
- Lens
- Retina
- Optic nerve



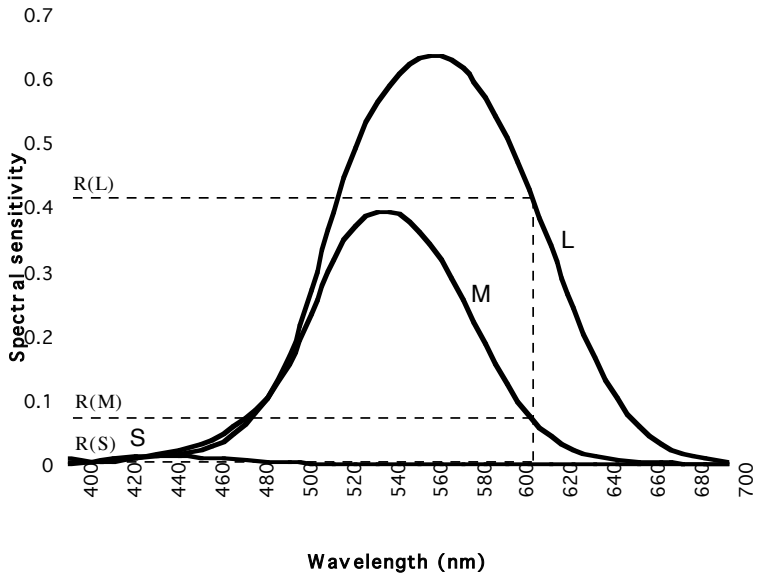
Physiology: Receptors

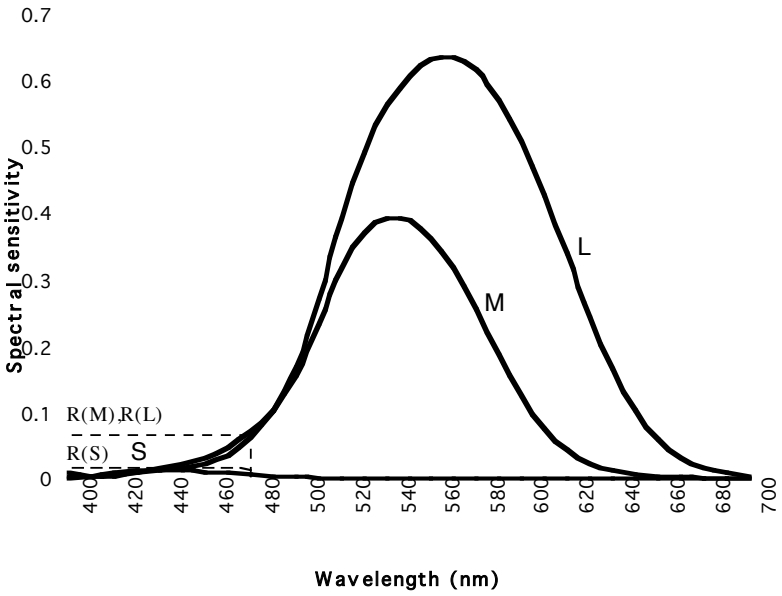
- Rods
  - active at low light levels (scotopic vision)
  - only one wavelength sensitivity function
- Cones
  - active at normal light levels
  - three types: sensitivity functions with different peaks

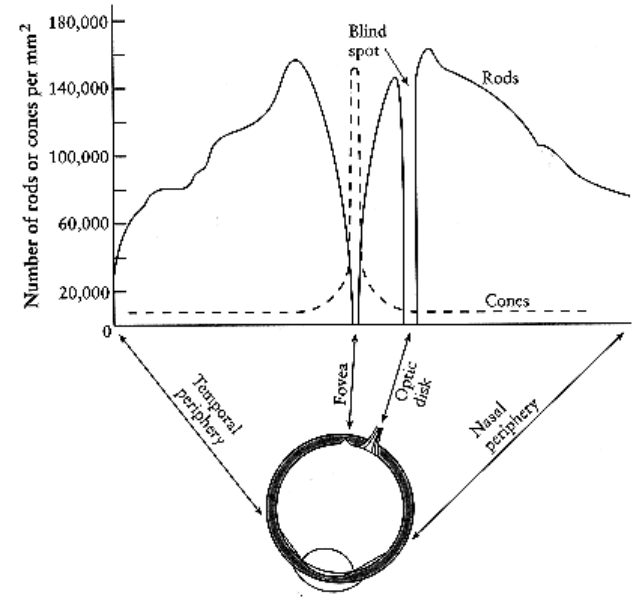
Cone Sensitivity Functions



- Glassner '95, p. 16.

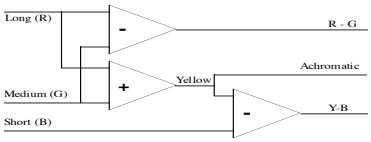



0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Spectral sensitivity
R(M),R(L)
R(S)
S
L
M
400
420
440
460
480
500
520
540
560
580
600
620
640
660
680
700
Wavelength (nm)


180,000
140,000
100,000
60,000
20,000
0
Number of rods or cones per mm²
Blind spot
Rods
Cones
Temporal periphery
Fovea
Optic disk
Nasal periphery

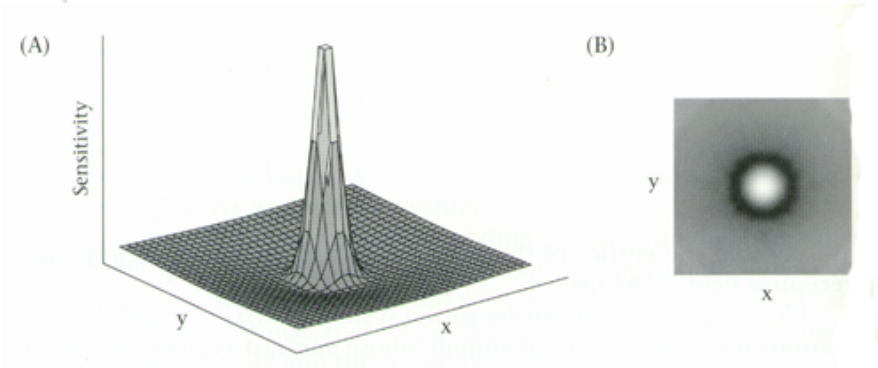
Physiology: Ganglia

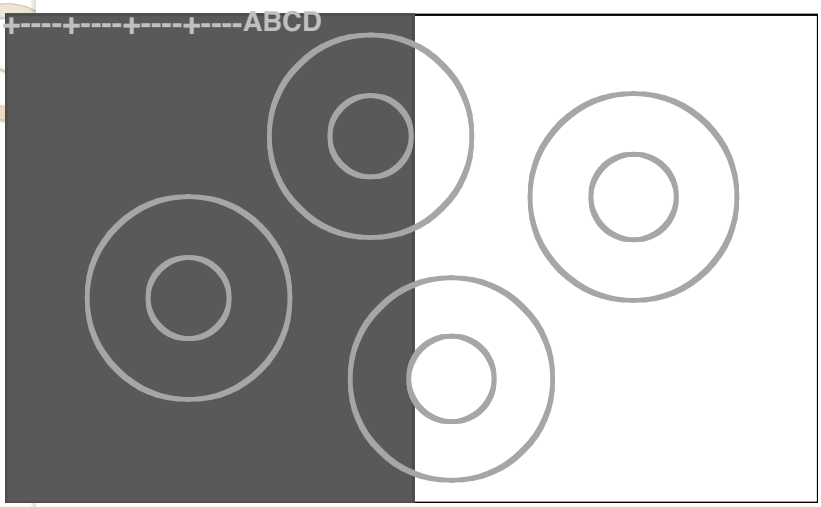
- Transform incoming SML into opponent color responses
  - M - L
  - Y - S (Y = L+M)
  - W (W ≅ L+M)



- Characteristics
  - concentric receptive fields
  - logarithmic response of receptors
  - adaption

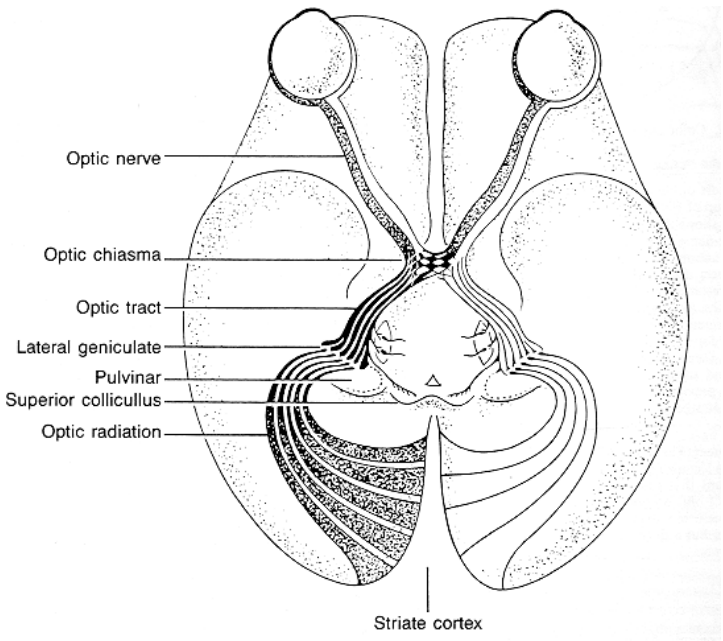
Center-surround Receptive Fields





Physiology: Brain

- Lateral geniculate nuclei
  - assemble data for single side of visual field
  - 2 monochromatic layers => magnocellular path
  - 4 chromatic layers => parvocellular path
- Visual cortex
  - orientation
  - end-stopped
  - occular dominance
  - spatial frequency
- Feedback from cognitive levels to earlier stages



Magnocellular Division

- Role in vision
  - identify objects and boundaries
  - depth perception
  - motion perception
- Characteristics
  - color: achromatic
  - acuity: large RF centers
  - speed: fast, transient response

Parvocellular Division

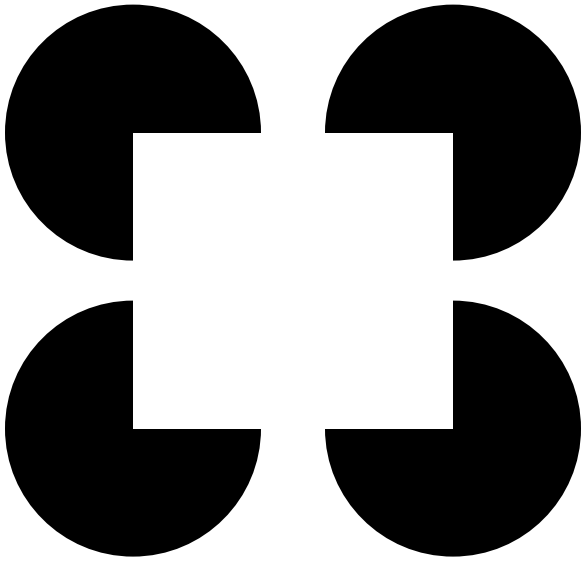
- Role in vision
  - discrimination of fine detail
  - color
- Characteristics
  - color: sensitive to wavelength variations
  - acuity: small RF centers
  - speed: relatively slow response

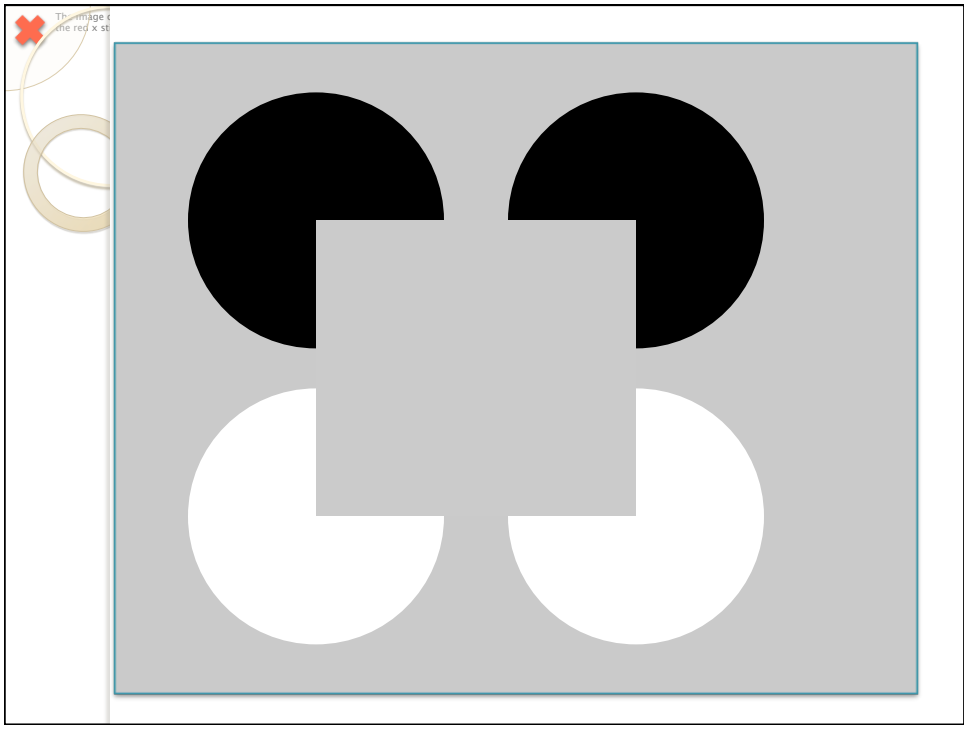
Human Visual Characteristics

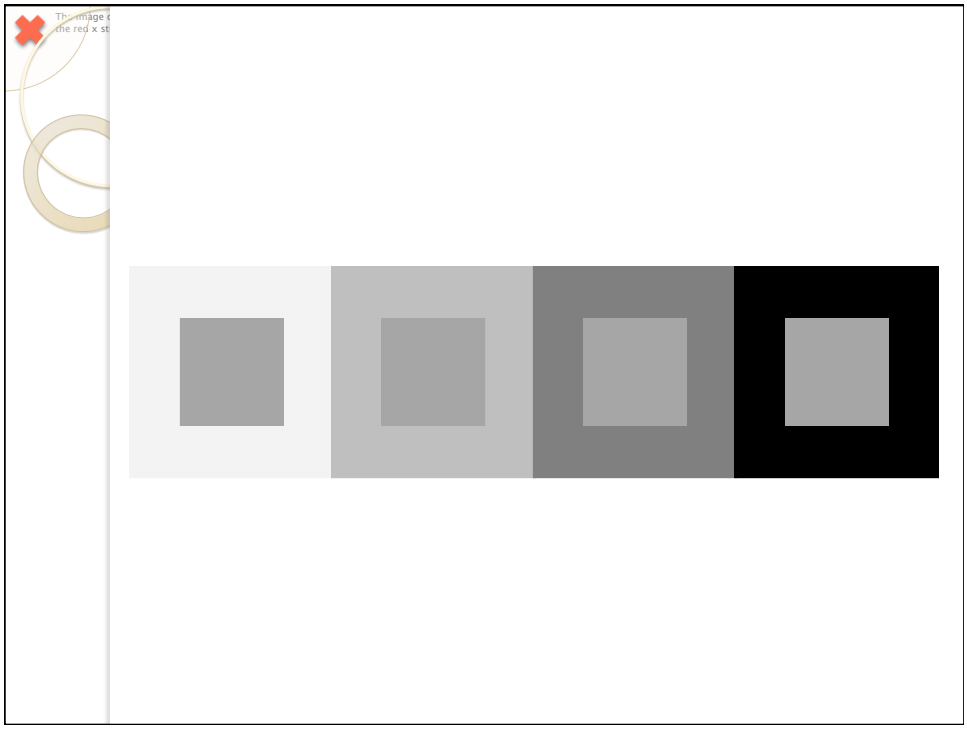
- Contrast sensitivity influenced by spatial frequency
- Adaption
- Communication between neighboring receptors

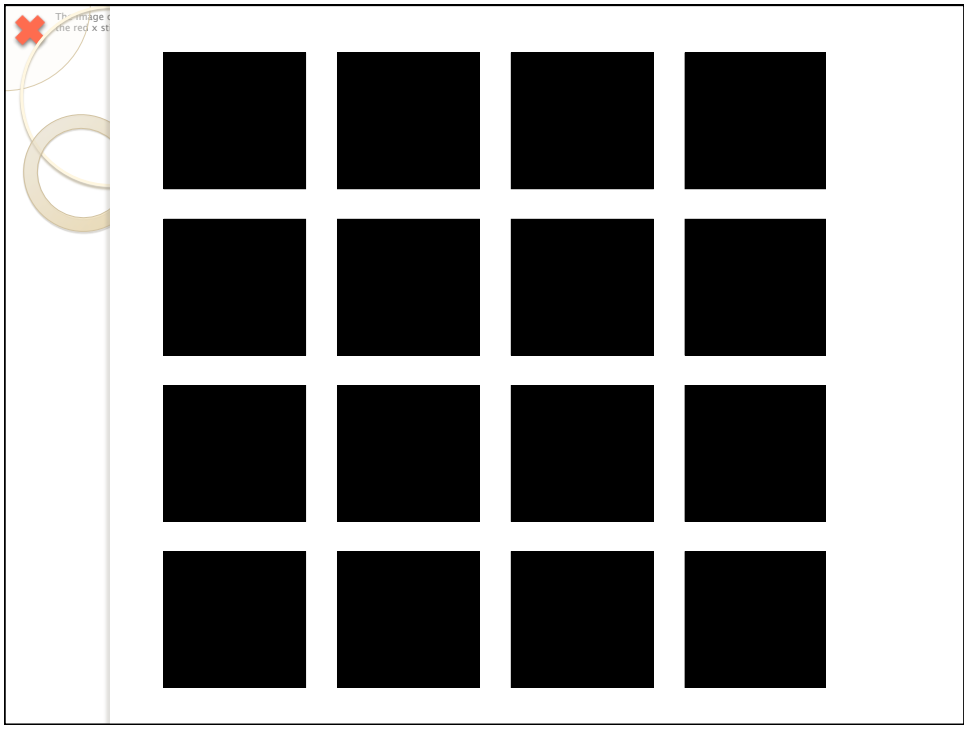
Communication among Receptors

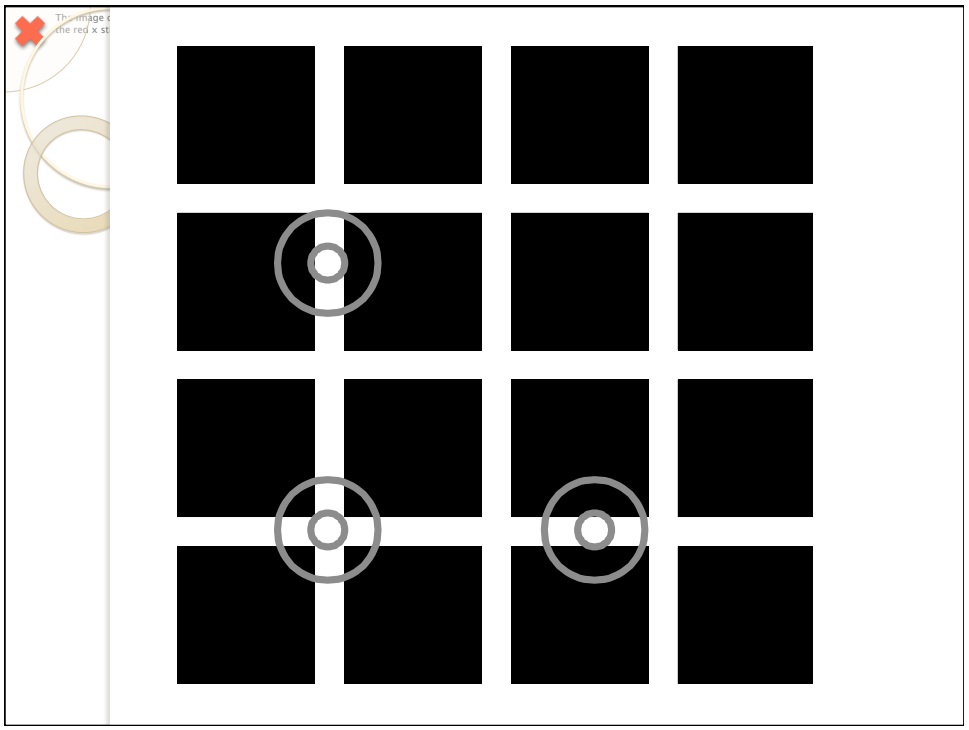
- Edge completion: subjective contours
- Relative judgements
  - intensity
  - size
  - slope
- Constancy
  - lightness
  - simultaneous contrast
- Tolerance of noise

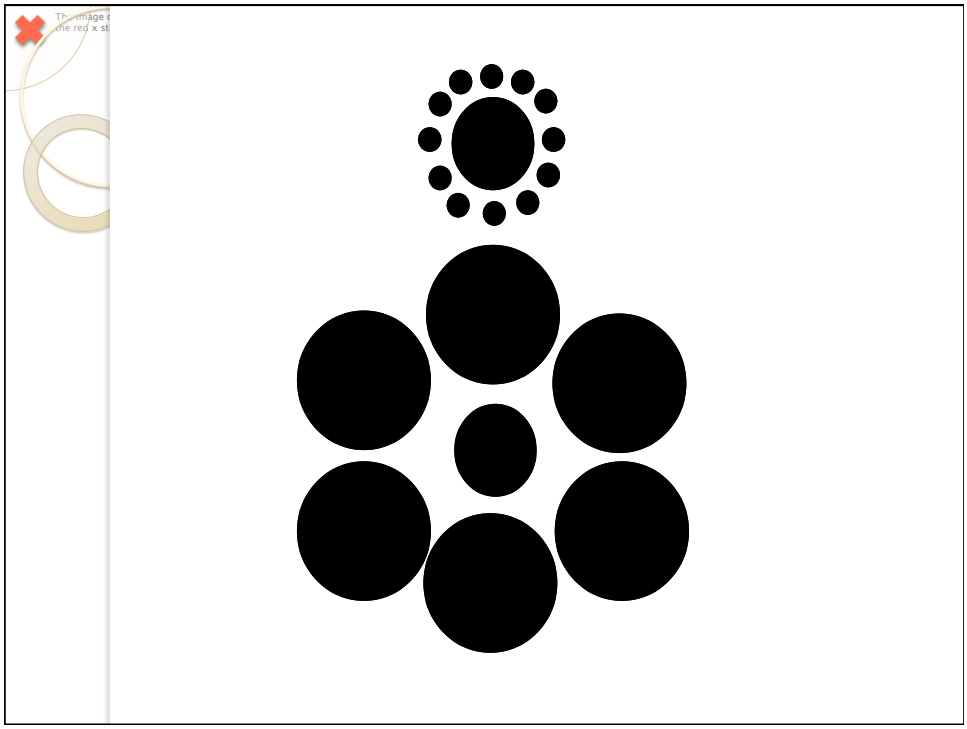


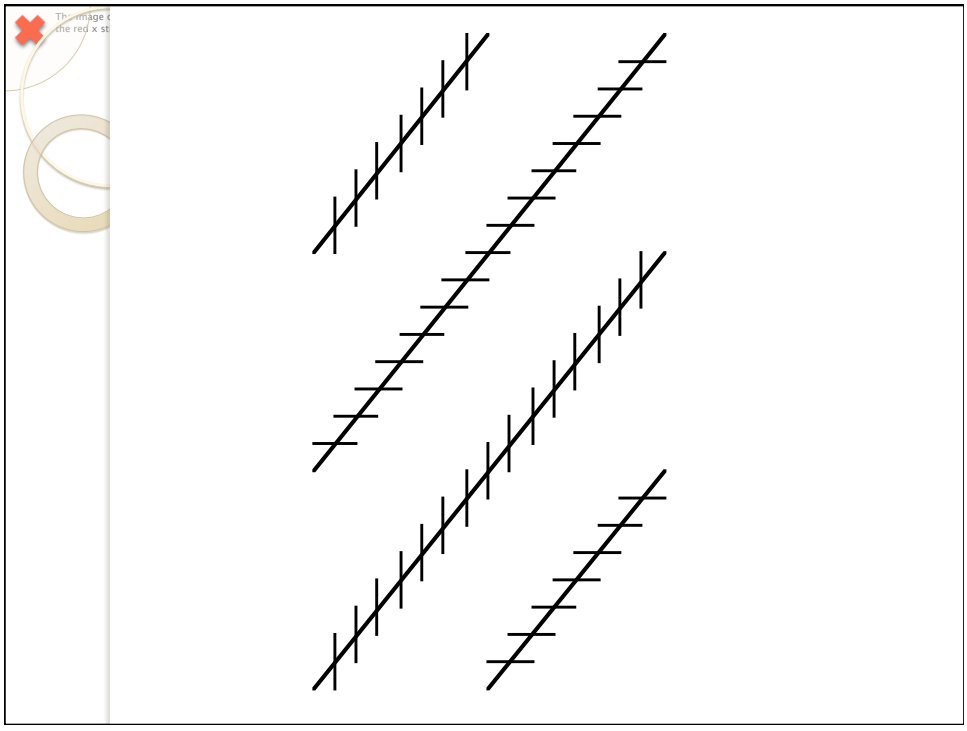


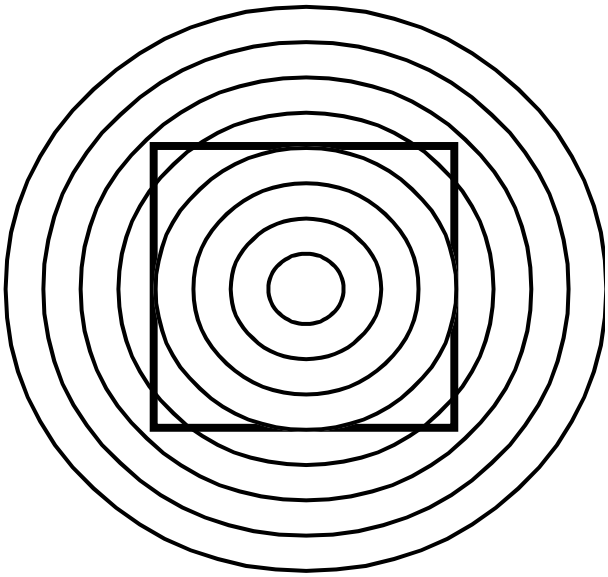












Depth Perception

Magnocellular Division

- Discriminates objects from one another
- Characteristics (relative to parvocellular path)
  - color : insensitive to wavelength variations
  - acuity : larger RF centers
  - speed : faster and more transient response
  - contrast : more sensitive to low contrast stimuli
- Observed characteristics of motion perception
  - color-blind: impaired at equiluminance
  - quickness
  - high contrast sensitivity
  - low acuity : impaired at high spatial frequencies

Depth Pathway

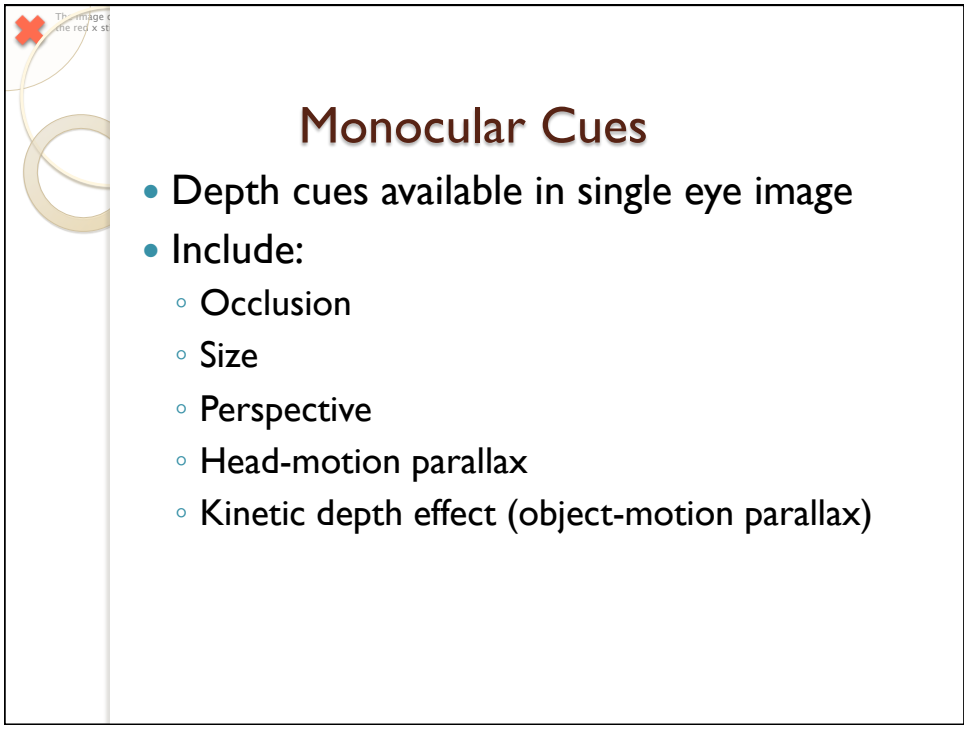
- Red and green cones
- Type A retinal ganglion cells
- Magnocellular layers in LGN
- Primary visual cortex
  - disparity tuned neurons (thick stripes in V2)
- Middle Temporal Lobe (MT)

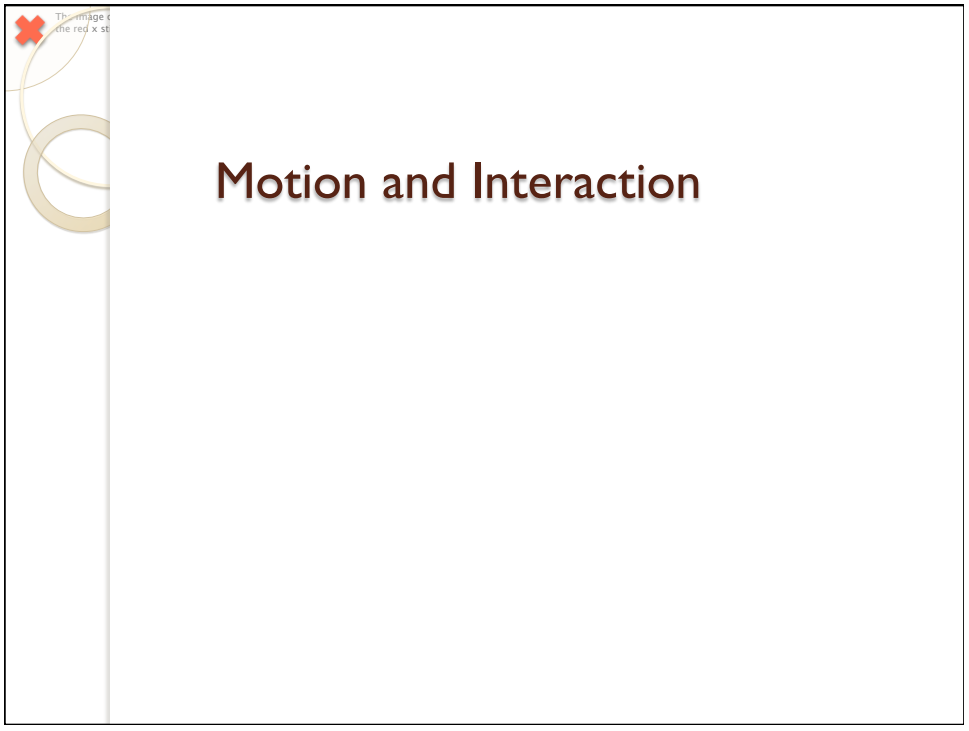
Motor Cues

- Vergence
- Accomodation

Binocular Cues

- Depth cues resulting from two views (one from each eye)
- Include:
  - retinal disparity (stronger for close objects)
  - neurons sensitive to particular disparities


Monocular Cues
• Depth cues available in single eye image
• Include:
◦ Occlusion
◦ Size
◦ Perspective
◦ Head-motion parallax
◦ Kinetic depth effect (object-motion parallax)


Motion and Interaction

Roles of Motion Processing

- Required for Pattern Vision
- Driving Eye Movements
- Time to Collision
- Exproprioceptive Information
- Perception of Moving Objects
- Depth from Motion
- Encoding 3D Shape
- Image Segmentation

Characteristics of Motion Perception

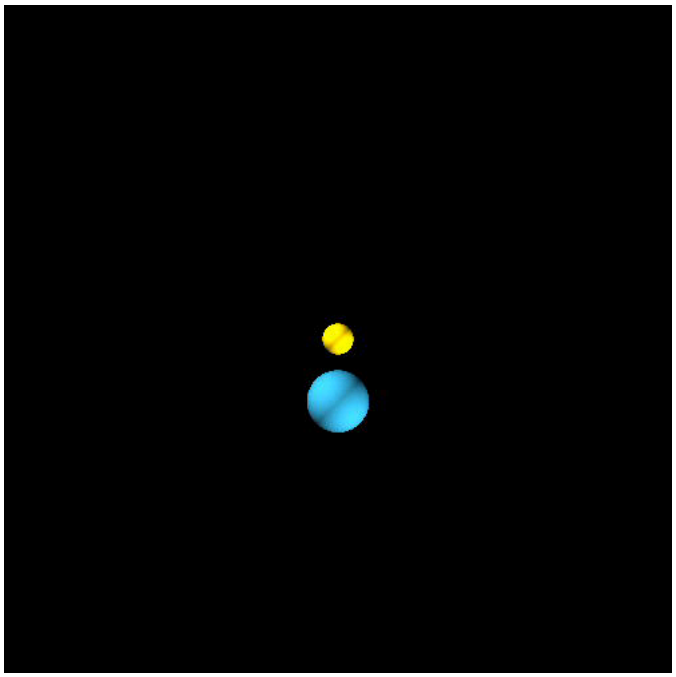
- Fundamental, independent visual process
  - motion aftereffects
  - motion blindness
- Based primarily on brightness
- Ability to interpret structure degrades in periphery
- Spatio-temporal interactions

Motion Pathway

- Red and green cones
- Type A retinal ganglion cells
- Magnocellular layers in LGN
- Area 4B in primary visual cortex
  - direction selectivity
  - velocity selectivity
  - expansion/contraction of visual field
  - global rotation
- Middle temporal lobe

Apparent Motion

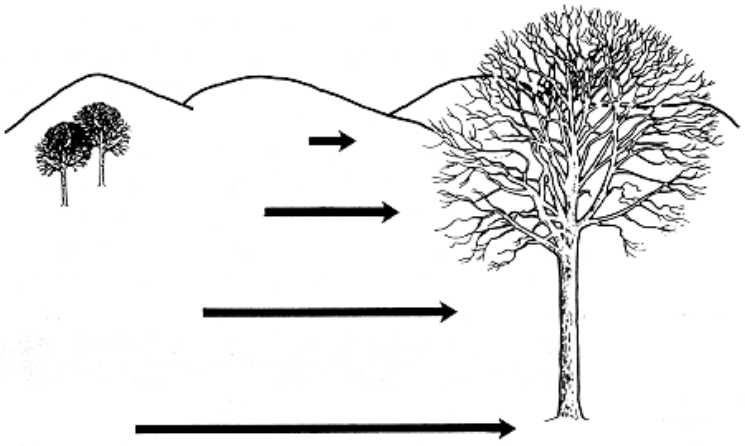
- Def: perception of motion without stimulus continuity (stroboscopic and cine)
- Influences
  - spatial frequency characteristics
  - global field effects
  - number of frames
  - expectations from reality
- Limitations
  - maximum of 300 msec interstimulus interval
  - decreased size constancy (max ~8 Hz)
  - decreased sense of observer motion



Depth from Motion

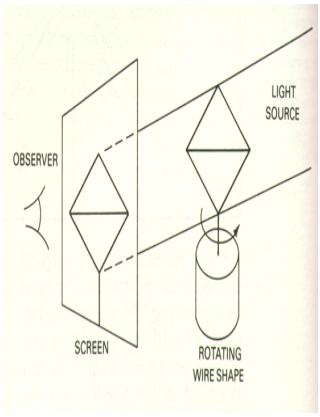
- Motion depth cues
  - head motion parallax
  - kinetic depth effect
  - magnitude of motion indicates relative depth
- Applications
  - indicating relative object positions
  - compensating for lack of other depth cues
- Limits
  - relative, not absolute depth
  - perceived size, perceived depth related

Head Motion Parallax

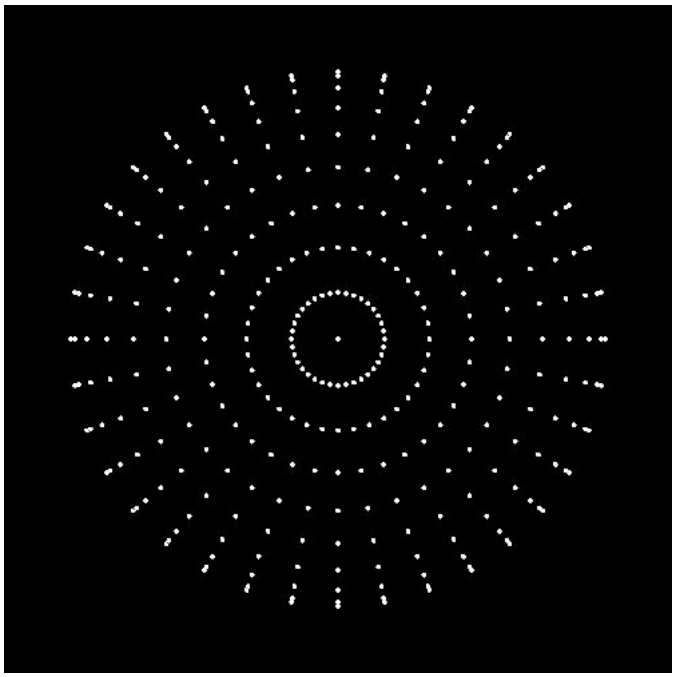


- Bruce and Green '90, p. 231.

Kinetic Depth Effect



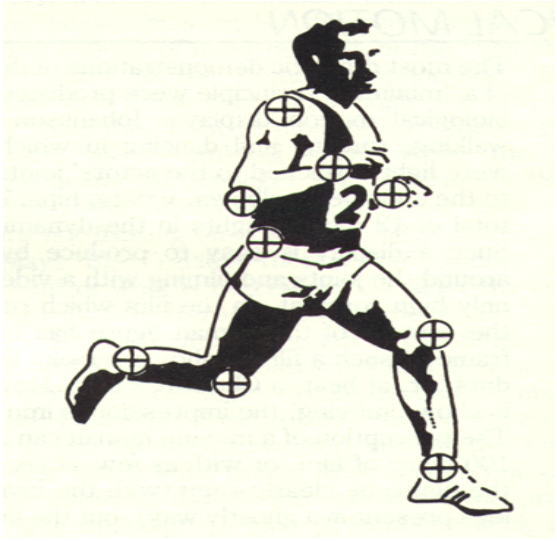
- Bruce and Green '90, pg. 162.



3D Structure from Motion

- Relative motion conveys info about 3D shape
- Rigidity assumption
- Applications
  - understanding of irregular/unfamiliar shapes
  - disambiguation of 2D projections
- Limits
  - 2 frames (large number of structured points)
  - 2-3 points (many frames)
  - 15 arc min (maximum displacement)

Structure from Motion



- Bruce and Green '90, pg. 328.

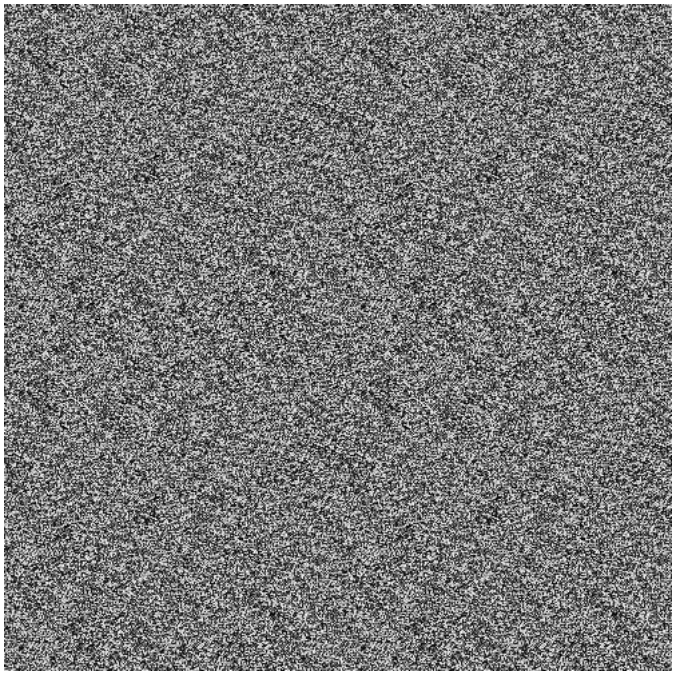


Image Segmentation

- Discontinuities in optical velocity field indicate object boundaries
- Boundaries can be detected on the basis of motion alone
- Applications
  - disambiguation of complex scenes
  - grouping of similar objects

At Equiliminance

- Motion perception of gratings degrades
- Depth perception disappears
- Depth from relative motion disappears
- Shape from relative motion disappears

Data, Tasks, and Clients

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Data Visualization

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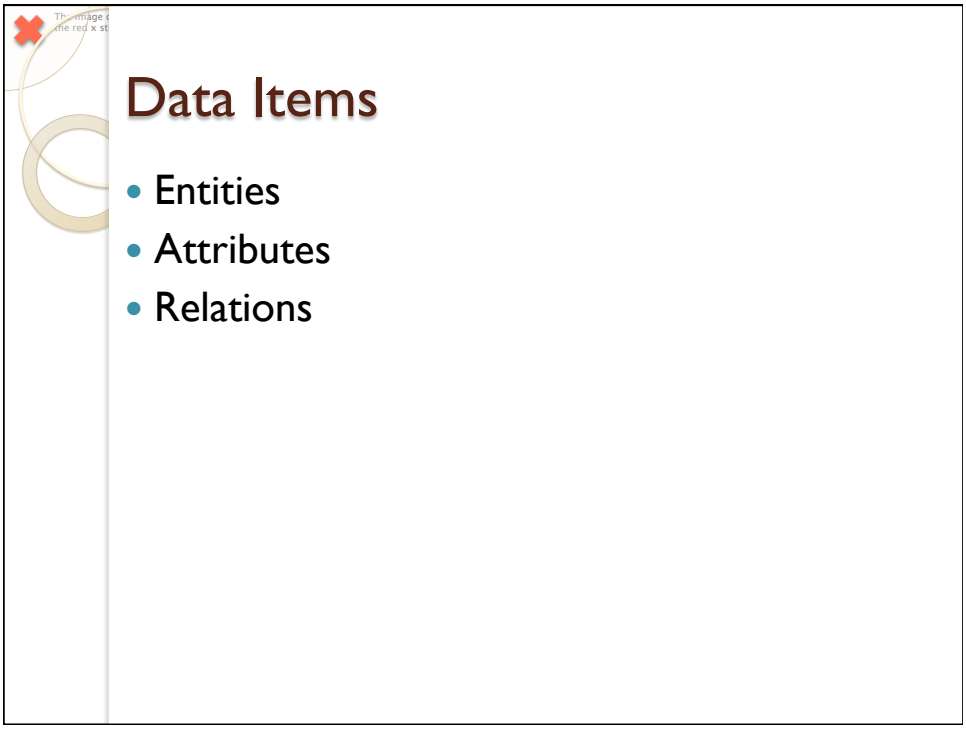
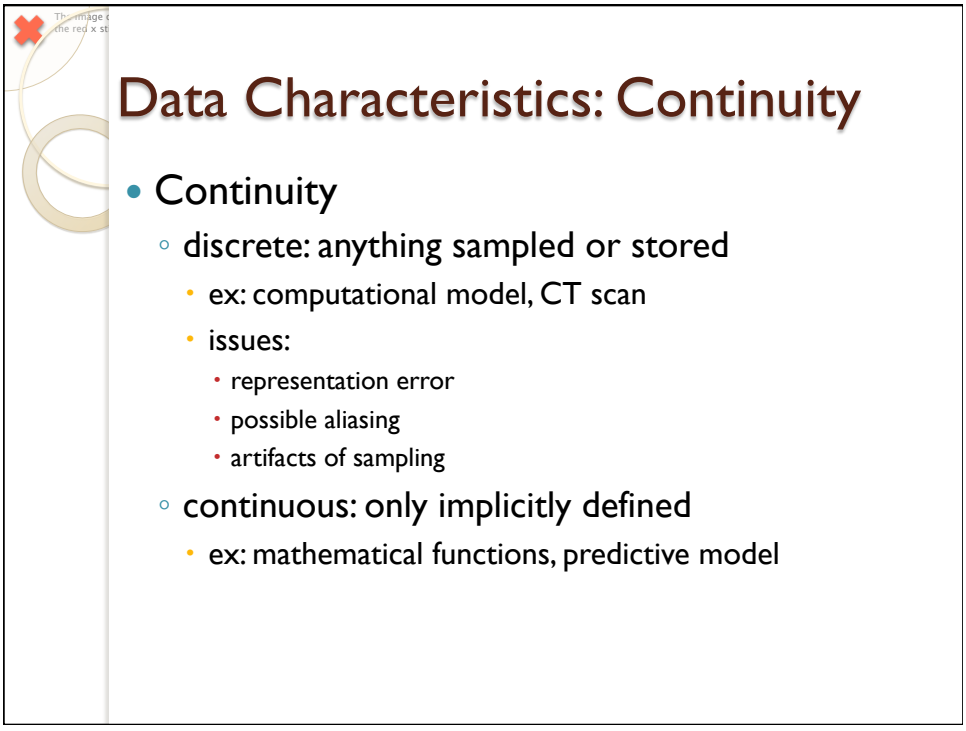
Data Taxonomy

- Can characterize data by its characteristics
- Can generalize about data with similar characteristics
  - potential problems
  - natural visualization techniques
  - ease of implementation



Data Items

- Entities
- Attributes
- Relations

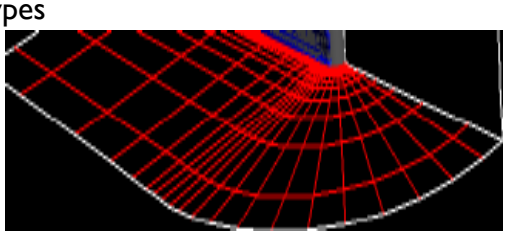


Data Characteristics: Continuity

- Continuity
  - discrete: anything sampled or stored
    - ex: computational model, CT scan
    - issues:
      - representation error
      - possible aliasing
      - artifacts of sampling
  - continuous: only implicitly defined
    - ex: mathematical functions, predictive model

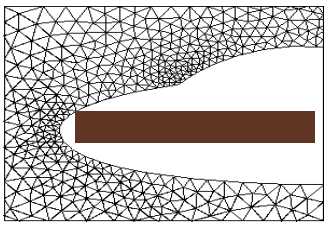
Data Characteristics: Structure

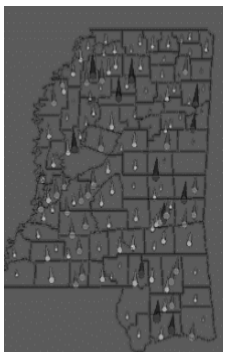
- Geometry vs Topology
- Topological Structure
  - Structured
    - Inherent spatial relationship among points (gridded)
    - Common grid types
      - Regular
      - Rectilinear
      - Curvilinear
    - Advantages
      - easy computation
      - possibly efficient storage (for densely populated grids)



Data Characteristics: Structure

- Structure
  - Irregularly structured
    - non-grid connectivity
    - ex: FEM results, surface meshes
    - advantages:
      - flexibility
  - Completely unstructured
    - no known spatial relationship among points
    - ex: pollution monitors, documents, atoms
    - advantages:
      - flexibility
      - efficient storage (for sparsely populated grids)



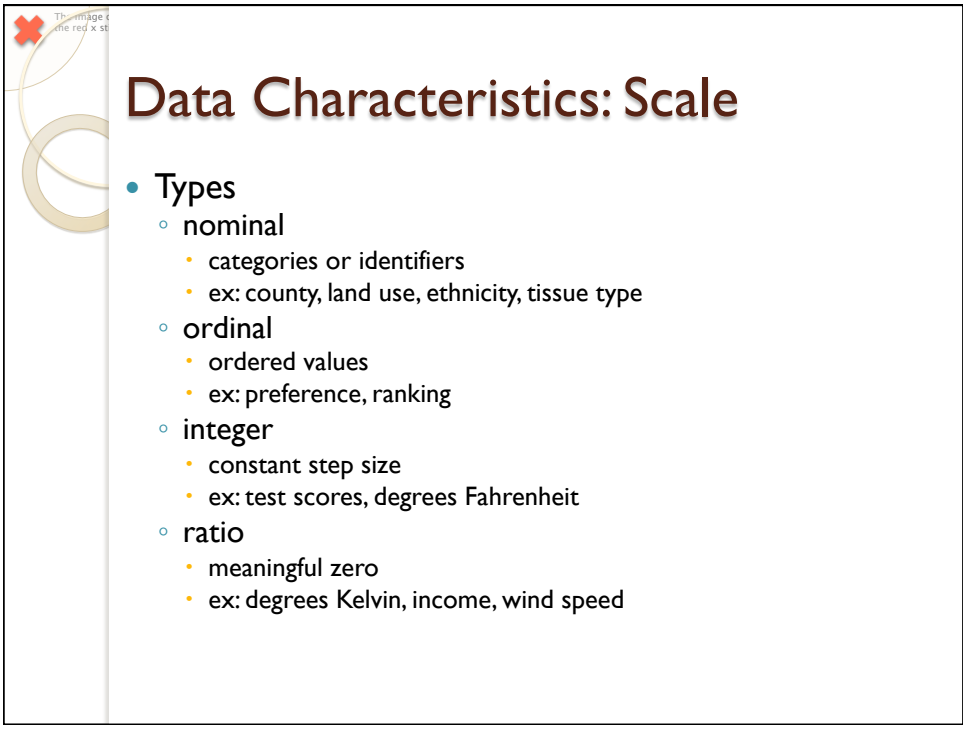


Data Characteristics: Dimension

- Dimensionality
  - # independent variables (usually # spatial/temporal variables)
  - commonly:
    - 2D
      - ex: weather info at ground, xray
    - 3D
      - ex: weather info in atmosphere, CT/MRI scan
    - *n* D
      - ex: census info, stock market conditions, document word frequency
  - Grid dimensions may differ from spatial dimensions

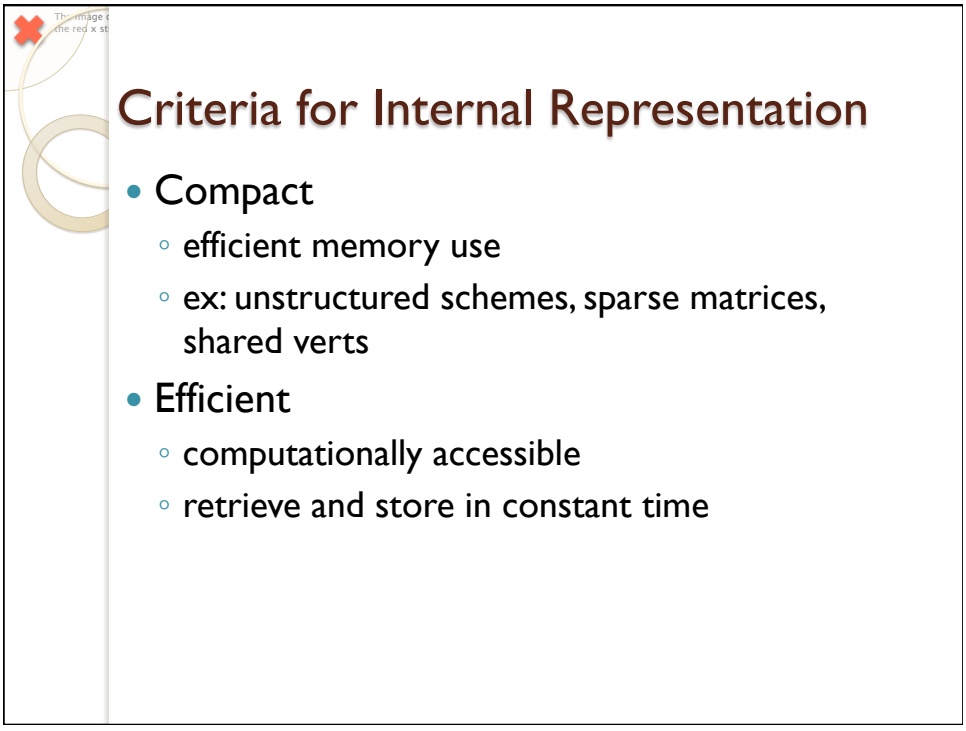
Data Characteristics: Multiple

- Number of variables per position
  - scalar
    - one value
      - ex: temperature, rainfall, or wind speed
  - multivariate:
    - multiple scalars
      - ex: temperature, rainfall, and wind speed
    - vector
      - ex: wind direction
    - tensor
      - ex: stress and strain forces
- Multivariate vs multidimensional



Data Characteristics: Scale

- Types
  - nominal
    - categories or identifiers
    - ex: county, land use, ethnicity, tissue type
  - ordinal
    - ordered values
    - ex: preference, ranking
  - integer
    - constant step size
    - ex: test scores, degrees Fahrenheit
  - ratio
    - meaningful zero
    - ex: degrees Kelvin, income, wind speed



Criteria for Internal Representation

- Compact
  - efficient memory use
  - ex: unstructured schemes, sparse matrices, shared verts
- Efficient
  - computationally accessible
  - retrieve and store in constant time

Criteria for Internal Representation

- Mappable
  - straight-forward conversions
    - native --> rep: simple conversion, no info lost
    - rep --> graphics prim: fast for interactive display
- Minimal coverage
  - manageable # options
  - few variants which work for wide variety of data
- Simple
  - easier to use
  - easier to optimize
  - errors less likely