

Comp/Phys/Mtsc 715

Pre-Attentive Characteristics:
Information that Pops Out

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Example Videos

- [Linked feature-map and 3D views for DTMRI](#)
- [Parallel Coordinates, slice, 3D for Astro-Jet](#)
- Vis 2011: Waser: [Ensemble simulation](#)

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Administrative

- Homeworks
 - HW1 turn in by midnight
 - Tomorrow-Monday, comment
 - HW2 posted

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Administrative

- What comments do we make?
 - First three are numerical scores from 1-5 for how well you could answer questions 1-3 looking at the design:
 - 1: I knew the answer before looking, but still can't see it
 - 2: Very challenging to see the correct answer
 - 3: I can see the answer if I look carefully
 - 4: I can see the answer fairly easily
 - 5: The answer is immediately obvious
 - Next is "Favorite parts"
 - Final are particular recommendations for improvement (different color map, spacing, technique and why this is better based on Visual System).

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Team Dynamics

- Working in teams is...
 - Good, because you can do more work
 - Hard, because of scheduling, communication, expectation management
- Scheduling: Right After Class Find Partner
- Communications/Expectation Management
 - Default: Work together on this at the same time
 - Clearly split the work and provide hard deadlines
 - Everyone participates equally: one member not supposed to be doing all the work

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Pop Quiz!

- What are the four types of scalar fields?
- What continuous color map shows interval data well?
- What type of data is best mapped to transparency?
- What is the average airspeed velocity of a swallow?

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“The eyeball as an information-gathering searchlight”

- How to attract its attention?
- How to enable it to attend to individual details?
- How to enable it to perceive emergent patterns?
- How to do all this in a fraction of a second?

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Lord of the Rings

- Eye of Sauron searching
 - Ring-bearer springs quickly to sight
 - Palantir seeing-stone viewers spring quickly to sight (Saruman trapped this way)
 - Things moving nearby on the plains of Mordor not seen so easily (Frodo and Sam hiding in the cracks to avoid this, Aragorn distracts the eye)



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Eye movements: How the Searchlight Seeks

- Saccades
 - Ballistic movements between fixation points
 - Dwells 200-600ms, sweeps in 20-100ms
 - We don't see much during the sweep
 - Eyes converge/diverge, refocus when object moves in Z
- Smooth pursuit
 - Lock on to object moving in field of view
 - Can move head and body while doing
 - Eyes converge/diverge, refocus as object moves in Z

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How Large is the Searchlight?

- “Useful Field of View”
 - When reading text, size of fovea (one word at a time)
 - When looking for patterns, can be much larger
 - Varies with target density to maintain a constant number of targets in attended region (Scaling down the display doesn’t help fit more!)
 - Scales down as cognitive load (or stress) increases

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Attracting the Searchlight

- Four requirements for interrupt
 - Easily perceived even if outside attention focus
 - Can be ignored, but continually reminds
 - Not so irritating that it makes use unpleasant
 - Be able to display various levels of urgency

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Attracting the Searchlight (2)

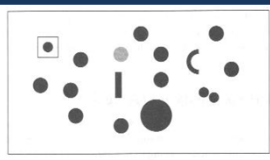
- What doesn’t work
 - Small targets in periphery
 - Changes in color outside fovea
 - Things happening during a saccade
 - Single change in icon appearance (flag up)
- What works
 - Auditory cues are very well suited to this
 - Motion UFOV >> static UFOV
 - At least 40 vs. 4 degrees, maybe whole field
 - Blinking (slightly irritating) or moving targets
 - Urgency coded to motion velocity

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Pre-attentive: What Can we see Quickly?

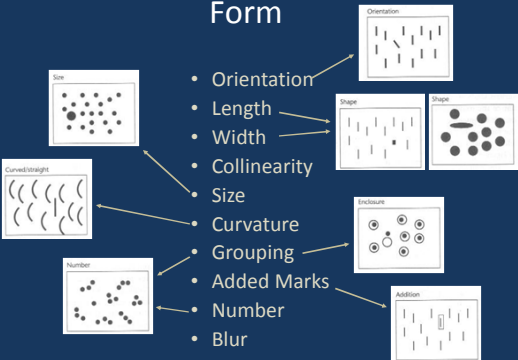
- Certain features cause objects to “pop out”
 - Enables showing things “at a glance”
 - Enables discovery in moving images
- Finding feature within distracters happens independently of number of distracters
- Several categories
 - Form
 - Color
 - Motion
 - Spatial Position



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Form

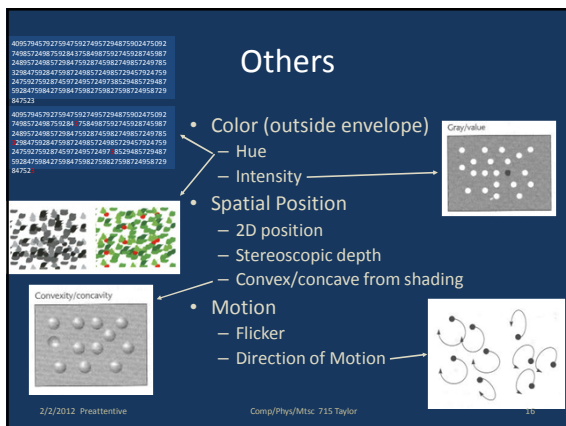
- Orientation
- Length
- Width
- Collinearity
- Size
- Curvature
- Grouping
- Added Marks
- Number
- Blur



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Others

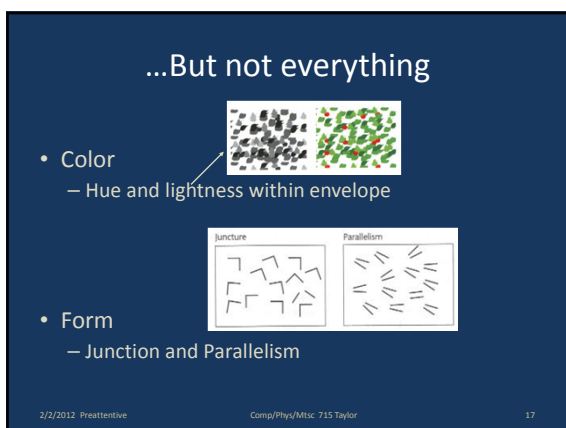
- Color (outside envelope)
 - Hue
 - Intensity
- Spatial Position
 - 2D position
 - Stereoscopic depth
 - Convex/concave from shading
- Motion
 - Flicker
 - Direction of Motion



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...But not everything

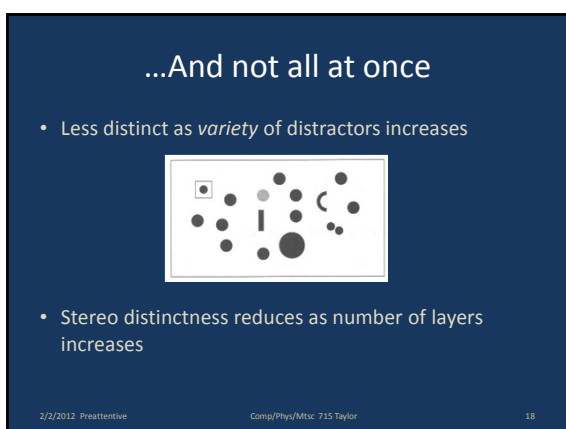
- Color
 - Hue and lightness within envelope
- Form
 - Junction and Parallelism



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...And not all at once

- Less distinct as *variety* of distractors increases
- Stereo distinctness reduces as number of layers increases



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Which is Most Distinct?

- ... it depends
 - This statement could be the theme for this course!
- Rules of thumb:
 - Adding marks to highlight better than removing
 - More than 4 items in a group require counting
 - Color must lie outside the convex hull in CIE space of other object colors (see next slide)

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Outside Convex Hull

a.

b.


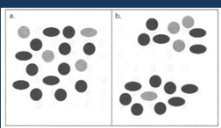
c.

d.

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Combining Features

- Most “and” searches are not pre-attentive
 - Square *and* gray
- Color/shape can be combined with spatial:
 - (ellipse *and* gray) *and*
 - Position/grouping
 - Stereo depth
 - shape from shading
 - motion

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How Does This Work?

- Incredible number of specialized receptors!
 - For each location on the retina (fovea mostly)
 - For features at several scales (larger off fovea)
 - Neurons with receptive fields tuned to...
 - On center, off surround; off center, on surround
 - Elongated blobs with particular orientation
 - Features moving with each different velocity
 - Color (R/G and B/Y signals)
 - Stereoscopic depth (match between eyes)
- Each tuned to detect a particular “Grapheme”

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Rich Feature Space


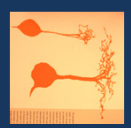
No regular grid or clock



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Operates Across Scale

- Focuses different type of sensors in different locations as needed
 - Color ~only in fovea
 - Motion ~only in surround

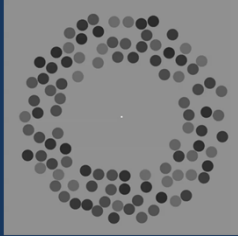


– Different receptive fields

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Filters act locally on retinal image

- [Link to Video1](#)
- [Link to Video2](#)
- [Link to Video3](#)
- [Link to Video4](#)

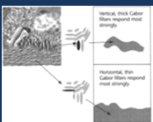
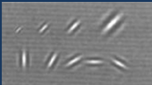
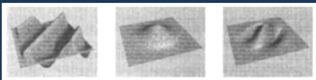


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Texture Graphemes

- Gabor Filter
 - $\cos(x) / \exp(x)$
 - Different scales and orientations
- Produce segmentation based on
 - Scale
 - Orientation
 - Contrast



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Uncertainty Principle Applied to Textures

- Cannot measure both size and orientation accurately at the same texture density
- Cannot produce texture with high resolution in space as well as high resolution in both orientation and size
- As scale is increased, the number of texture elements per unit area must be reduced

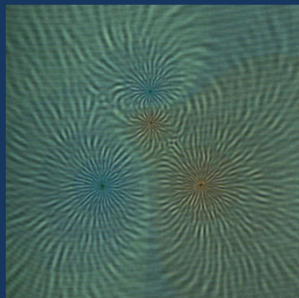
- Additionally, the human visual system has scale of cosine and exponential coupled on most detectors: can see fine detail in small areas and larger features in larger areas

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Two-Valued Texture Map

- Field direction
 - Orientation

- Field strength
 - Size (inverse)
 - Why invert?
 - Saturation
 - Double-ended

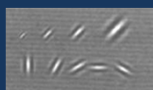


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Four-Value Texture Map?

- Randomly splat lots of Gabor functions
 - Data 1 → Orientation (differ by 30 degrees)
 - Data 2 → Size (Differ by factor of 3)
 - Data 3 → Contrast
 - Data 4 → Hue

- I'd want to see it to believe it
 - More on this in the Multivariate lecture



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Texture and the Prying Eye

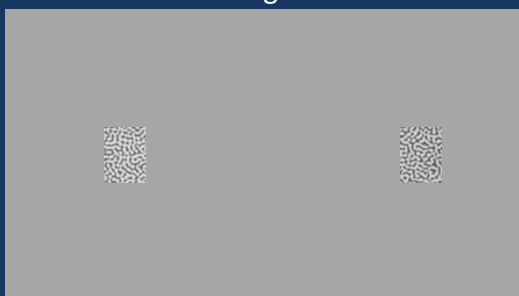
- Pre-attentive (from before)
 - Texture scale vary by factor of 3
 - Texture orientation vary by 30 degrees
- Just-noticeable difference
 - Texture scale vary by 9 percent
 - Texture orientation vary by 5 degrees

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Difference Detectors at it again



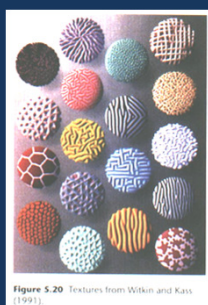
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Again, Texture Space is Richer than this

- Lots of studies of Color
- Few of texture
- Potentially large space



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Counting White-Shirted Passes...

- <http://viscog.beckman.uiuc.edu/flashmovie/15.php>

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Other Web Resources

- Change-blindness video
 - <http://www.youtube.com/watch?v=voAntzB7EwE>
- Chris Healey's page on perception:
 - <http://www.csc.ncsu.edu/faculty/healey/PP/index.html>

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Design Choice Quiz!

- From the 2010 CASE Cumulative Exam

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Credits

The pre-attentive/texture lecture and all the images in it are taken from Colin Ware's book [Information Visualization](#), mostly from Chapter 5.

Okay, so the [Lord of the Rings](#) slide isn't from there...
