Lecture 5: Perception
Information Visualization
CPSC 533C, Fall 2006
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Readings Covered

- Ware, Chapter 5: Visual Attention and Information That Pops Out
- Ware, Chapter 6: Static and Moving Patterns

Human Perception

- sensors/transducers
- psychophysics: determine characteristics
- relative judgements: strong
- absolute judgements: weak
- continuing theme
- different optimizations than most machines
- eyes are not cameras
- perceptual dimensions not nD array
- (brains are not hard disks)

Foveal Vision

- thumbnail at arm’s length

Foveal Vision

- thumbnail at arm’s length
- small high resolution area on retina

Equal Legibility

- if fixated on center point

Eyes

- saccades [video]
- fovea: high-resolution samples
- brain makes collage
- vision perceived as entire simultaneous field
- fixation points: dwell 200-600ms
- moving: 20-100ms

Ears

- perceived as temporal stream
- but also samples over time
- hard to filter out when not important
- visual vs auditory attention
- implications
- harder to create overview?
- hard to use as separable dimension?
- 'sonification' still very niche area
- alternative: supporting sound enhances immersion

Other Modalities

- barrier: lack of record/display technology
- haptics maturing
- "haptic visualization" very new
- smell, taste
- out-there SIGGRAPH ETech demos
- characterization possible after technology barriers fall

Foveal Touch

- star-nosed mole

Psychophysical Measurement

- JND: just noticeable difference
- increment where human detects change
- average to create "subjective" scale
- low-level perception more uniform than high-level cognition across subjects

Nonlinear Perception of Magnitudes

- sensory modalities not equally discriminable

Dimensional Dynamic Range

- linewidth: limited discriminability

Dimensional Ranking: Accuracy

- spatial position best for all types

Cleveland vs. Mackinlay: Quantitative

- Mackinlay: position along common scale
- Cleveland: position along nonaligned scales

Cleveland example: frame increases accuracy

Weber’s Law

- ratio of increment threshold to background intensity is constant
- relative judgements within modality
- $\frac{\Delta I}{I} = K$

**Cleveland Suggestions**

- dot chart over pie or bars
- direct differences over superimposed curves
- framed rectangles over shading on maps

**Preattentive Visual Dimensions**

- color (hue) alone: preattentive
  - attentional system not invoked
  - search speed independent of distractor count
- shape alone: preattentive
- combined hue and shape (demo)

**Many Preattentive Visual Dimensions**

- hue
- shape
- texture
- length
- width
- orientation
curvature
intersection
flicker
direction of motion
stereoscopic depth
light direction, . . .

**Glyphs: Bray**

- composite graphical mark
- encoding using multiple dimensions
- large-scale individual glyphs vs. small-scale texture fields
  - grouping into large-scale patterns
- integral vs. separable analysis
  - when do they help?

**Gestalt Laws**

- principles of pattern perception
  - "gestalt": German for "pattern"
  - original proposed mechanisms wrong
  - rules themselves still useful
- Pragnatz
  - simplest possibility wins

**Gestalt Principles**

- proximity, similarity, continuity/connectedness/good continuation
- closure, symmetry
- common fate (things moving together)
- figure/ground, relative sizes

**Proximity**

**Similarity**

**Continuity**

- smooth not abrupt change
- overrules proximity
Connectedness
- can overrule size, shape

Closure
- overrules proximity

Symmetry
- emphasizes relationships

Common Fate
- demo

Relative Size
- smaller components perceived as objects

Figure/Ground
- determined by combination of previous laws

Graph Drawing Tension
- node placement
- close
  - proximity
  - far
  - visual popout of long edge
  - either
  - connectedness
- tradeoffs abound in infovis!
- grammars
  - node-link graphs
  - maps

Motion
- works for preattentive/grouping
- less studied than static dimensions
  - Michotte on causality
  - newer infovis/motion work by Lyn Bartram
- biological motion
  - demo

Thinking With Viz
- problem solving loops
  - external representations
  - cognitive cyborgs
  - cost of knowledge
    - Pirolli/Rao: information foraging/scent theory
    - attention as most limited resource

Visual Working Memory
- characteristics
  - different from verbal working memory
  - low capacity (3-5)
  - locations egocentric
  - controlled by attention
  - time to change attention: 100 ms
  - time to get gist: 100 ms
  - not fed automatically to long term memory

Visual Working Memory
- multiple attributes per object stored
  - position (egocentric), shape, color, texture
    - integration into glyphs allows more info
  - change blindness (Rensink)
    - world is its own memory
  - inattentional blindness
  - attracting attention
    - motion (or appear/disappear?)

Memory and Loops
- long term memory
  - chunking
  - memory palaces (method of loci)
  - nested loops
    - problem-solving strategy
    - visual query construction
    - pattern-finding loop
    - eye movement control loop
    - intrasaccadic image-scanning loop

InfoVis Implications
- Rensink grad course taught every few years
    http://www.cs.ubc.ca/~rensink/courses/cpsc532E/
    http://www.psych.ubc.ca/~rensink/courses/psyc579/

More Perception
- visual query patterns
- navigation/interaction cost
- multiple window vs. zoom