Interactive Information Visualization

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Outline

information visualization motivation
designing for humans
information visualization techniques
future directions

Information visualization

interactive visual representation of abstract data
help human perform some task more effectively

Interactivity

static images
10,000 years
art, graphic design

moving images
100 years
cinematography

interactive graphics
20 years
computer graphics, human–computer interaction

Visualization Tasks

overview
zoom
crop
details–on–demand

relate
history
extract

(Task has it: A Task by Data Type Taxonomy for Information Visualizations. Ben Shneiderman. citeseer.ist.psu.edu/shneiderman05eyes.html)

Task-oriented design

custom design for checking semantic networks
reading definition subgraph labels

Task-oriented design

previous general methods
Design/tradeoffs
information density vs. visual salience

Scientific vs. information visualization
scvis: inherently spatial data
  fluid flow over airplane wing
infovis: abstract data, choice of spatialization
  FilmFinder

Example: node-link graphs
powerful abstraction
common in many domains

Why visualize graphs?
Example: book topic relationships
  [Godel, Escher, Bach, Hofstadter 1979]

Why visualize graphs?
offload cognition to visual systems
  minimal attention to read answer

Why draw graphs automatically?
manual: hours, days
  automatic: seconds
  [Godel, Escher, Bach, Hofstadter 1979]
  [Cannen et al 93]

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Human Perception
sensors/transducers
  psychophysics: determine characteristics
relative judgements: strong
  absolute judgements: weak
different optimizations than most machines
  eyes are not cameras
  perceptual dimensions not nD array
  (brains are not hard disks)
limits of intuition
  thoughts, goals, plans: accurate
  vision, hearing, attention, memory: inaccurate
Nonlinear perception of magnitudes

sensory dimensions not equally discriminable
JND: Just Noticeable Differences
Stevens power law

Eyes
foveal vision
high resolution
thumbnail at arm’s length
saccades [video]
high-resolution samples, brain makes collage
vision perceived as entire simultaneous field
dwell 200–600ms, moving: 20–100ms

Fovea
low–res periphery, high–res sensor
general concept, not just for eyes
foveal touch: star–nosed mole

Preattentive visual dimensions

Preattentive visual dimensions

many preattentive dimensions of visual modality
hue
shape
texture
length
width
size
orientation
curvature
intersection
intensity
flicker
direction of motion
stereoscopic depth
lighting direction

Well, actually...
sometimes works (motion + color)
but need both preattentive and cognitive
for, say, designing visualizations

Preattentive visual dimensions

color alone: preattentive
shape alone: preattentive
combined hue and shape: multimodal
requires attention
search speed linear with distractor count

Integral vs. separable dimensions

red–green
yellow–blue
x–size
y–size
orientation
shape
motion
color
location

(Colin Ware, Information Visualization: Perception for Design, Morgan Kaufmann 1999)
**Data types**

- **continuous (quantitative)**
  - 10 inches, 17 inches, 23 inches

- **ordered (ordinal)**
  - small, medium, large

- **categorical (nominal)**
  - apples, oranges, bananas

**Dimensional ranking

**Dimensional ranking varies by data type**

- **Quantitative**
  - Position
  - Length
  - Angle
  - Slope
  - Area
  - Volume
  - Density
  - Saturation
  - Hue

- **Ordinal**
  - Position
  - Density
  - Saturation
  - Hue
  - Length
  - Angle
  - Slope

**Visual Encoding Example**

**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

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**Color rules of thumb**

- **nominal**
  - bad: > 12 hues
  - good: use <= 12 hues

- **ordinal**
  - bad: using hue
  - good: saturation/brightness

- **quantitative**
  - bad: rainbow colormaps
  - good: interpolate between two hues
**Colormaps**
rainbow colormaps usually bad idea
hue is mediocre for showing order
not perceptually linear

[Image]

**Overview+detail**
problem
avoid user disorientation when inspecting detail
hard for big datasets
bad: one window, must remember position

[Image]

**Overview and detail**
better: add linked overview window(s)

[Image]

**Overview and detail**
SeeSoft: software maintenance
(colormaps: segmented vs. continuous)

[Image]

**Overview+detail**
Rivet: performance tuning
level of detail

[Image]

**Overview to detail to sorting**

[Image]

**Focus+context**
linked windows
still have cognitive load to correlate
good solution:
merge overview, detail into single window
fisheye views [Furnas 86], [Sarkar et al 94]
**Focus+context**
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merge overview, detail into single window
fisheye views [Furnas 86], [Sarkar et al 94]
nonlinear magnification [Keahey 96]

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**TableLens**
focus+context
power of sorting
www.tablens.com

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**Focus+context**
H3 [Munzner 97]
task: browsing large quasi-hierarchical graphs
[demo]

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**Global focus+context**
TreeJuxtaposer: comparing trees
linked highlighting
[demo]

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**Comparison**
bad: temporal, if many items
intermediate ones "overload mental buffer"
good: temporal blinking if two items

good: side by side
array of small multiples
creates overview

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**Minimizing occlusion**
bad: Midwestern occlusion

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**Minimizing occlusion**
good: show only start and end of lines

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**Minimizing occlusion: 3D vs. 2D**
bad: 3D pretty but not useful
metacognitive gap: lose by adding dimension
Minimizing occlusion: 3D vs. 2D

good: 2D display of category clusters

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Motion: clarify structure

navigation
rotate/translate/zoom
[demo: Gomview]

object recognition
moving lights at joints
Johansson 1973

animated transitions
avoid change blindness
smooth transition from one state to next
maintain object constancy

Future: scaling to huge datasets

data explosion

sensors
Human Genome Project
Sloan Digital Sky Survey

simulation
Accelerated Strategic Computing Initiative
microprocessor design

logging
long-distance telephony backbone
Web traffic

Future: scaling display resolution

always pixel-bound in past

high-res displays now available
4K x 2K: 9Mpixels vs 1 Mpixel
pixel rich

interactivity + resolution of paper
add physical navigation (walk closer) to virtual navigation

More Information

UBC Term 2 course: 533C Visualization
undergrads by consent of instructor

http://www.cs.ubc.ca/~tmm