Data Visualization as a Driver for Visual Cognition Research

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Interleaved structure

• **Things I Currently Say**
  – that draw on findings from visual cognition about how to visually encode and interact with information

• **Things I Wish I Knew**
  – where I’d love to see the visual cognition community do more work!
    • or to hear that the work exists and get pointers to it

[www.cs.ubc.ca/~tmm/talks.html#opam17](http://www.cs.ubc.ca/~tmm/talks.html#opam17)
We have many…

• **objects** (marks) on the display at once
• **visual channels** in use at the same time
• **views** visible side by side
• **tasks** that users switch between

[www.cs.ubc.ca/~tmm/talks.html#opam17](http://www.cs.ubc.ca/~tmm/talks.html#opam17)
Objects & channels

• marks (objects)
  – geometric primitives

• channels
  – visual depictions of magnitudes or categories
  – control appearance of marks to convey information

[Fig 5.2, 5.3 Visualization Analysis & Design. Munzner. CRC Press 2014.]

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Channels: Expressiveness types and effectiveness rankings

- **Magnitude Channels: Ordered Attributes**
  - Position on common scale
  - Position on unaligned scale
  - Length (1D size)
  - Tilt/angle
  - Area (2D size)
  - Depth (3D position)
  - Color luminance
  - Color saturation
  - Curvature
  - Volume (3D size)

- **Identity Channels: Categorical Attributes**
  - Spatial region
  - Color hue
  - Motion
  - Shape

- **channel rankings**
  - what’s the order?
  - what are the rough equivalence classes? (are these right?)
  - what are the metric distances between them?
  - wrt time (RT)? wrt error (accuracy)? tradeoffs?

- **channel capacity**
  - how many discriminable steps/bins/levels are there in each channel?
  - how does this change when multiple channels at once?

[Fig 5.5, 5.6, 5.9. Visualization Analysis & Design. Munzner. CRC Press 2014.]
Channels: Separability vs integrality

- Position + Hue (Color)
  - Fully separable: 2 groups each
- Size + Hue (Color)
  - Some interference: 2 groups each
- Width + Height
  - Some/significant interference
- Red + Green
  - Major interference: 4 groups total: integral hue
  - 3 groups total: integral area

• how (& how much) do the channels interfere with each other?
  – what other pairs? to what extent? what’s the effect for # discriminable steps?
  – what about triples? n-way interactions for n up to at least 5-6?
  – what about when there’s a lot of visual complexity in the scene: many objects?
    • 100? 1000? 10K? 1M?

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Many marks/objects, many channels, many tasks, many views

MizBee
https://youtu.be/86p7brwuz2g

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Channels: Shape

• shape
  – complex combination of lower-level primitives
  – many bins

• how does shape decompose into elements?
  – I want equivalent of L*a*b* color space, for “shape space”
    • quantitative metric with equal JNDs along axes
      – eg pointy-ness vs smoothness; open vs closed; …
    • use for deciding on encoding
    • use for interpolating values

[Fig 10.1. Visualization Analysis & Design. Munzner. CRC Press 2014.]

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Views: memory vs eyes

- interactive navigation within view
  - leverage spatial cognition, but rely on memory for previous states
Views: Interactive navigation within view

http://www.onezoom.org

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Views: memory vs eyes

• interactive navigation within view
  – leverage spatial cognition, but rely on memory for previous states

• side by side views
  – low cognitive load to move eyes between juxtaposed views
  – but reduced display area, each view has 1/N pixel budget

http://www.onezoom.org

www.cs.ubc.ca/~tmm/talks.html#opam17
Views: Multiple linked side by side

http://buckets.peterbeshai.com/

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Views: memory vs eyes

• interactive navigation within view
  – leverage spatial cognition, but rely on memory for previous states

• side by side views
  – low cognitive load to move eyes between juxtaposed views
  – but reduced display area, each view has 1/N pixel budget

• what’s the cost-benefit tradeoff of interactive navigation vs switching between multiple side by side views?
  – what mechanisms matter?
    • attention? memory? change detection?
  – does task switching between views affect how many objects people can track? can remember?
    • between 2 views? 3 views? 4? 5-10?

http://www.onezoom.org

http://buckets.peterbeshai.com
Tasks

- all possible pairs of \{action, target\}
  - discover distribution
  - compare trends
  - locate outliers
  - browse topology
  - compare shapes

• visual cognition concerns as lower-level operators
  - visual search
  - comparison
  - ensemble processing
  - what else?…

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[Fig 3.1. Visualization Analysis & Design. Munzner. CRC Press 2014.]
Summary

• (many) channels & objects
  - ranking, classes, metric distances, capacity
  - separability / interference
  - shape space
• views
  - tradeoffs of multiple views vs interactive navigation
• tasks
  - from low-level vision operators to high-level vis tasks

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Visualization Analysis and Design.
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