Analysis framework: Four levels, three questions

- domain situation: who are the target users?
- abstraction: translate from specific domain to vocabulary of vis
- task: what is shown? data abstraction
- why is the user looking at it? task abstraction

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- visual encoding: idiom: how to draw
- interaction: idiom: how to manipulate

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Why represent all the data?
Computer-based visualization systems provide visual representations designed to help people carry out tasks more effectively.

- summaries lose information, details matter
  - confirm expected and find unexpected patterns
  - assess validity of statistical model

Why analyze?
• imposes structure on huge design space
• scaffold to help you think systematically about choices
• analyzing existing as stepping stone to designing new
• most possibilities ineffective for particular task/class combination
•...
Data and Dataset Types

Attributes

Items

Items

Trees

Attributes (columns)

Items

Networks

Link

Node

Position

Dataset Types
• visualization vs computer graphics
– geometry is design decision

Attributes (columns)

Items

Multidimensional Table

Value in cell

Grid of positions

Geometry (Spatial)

Position

Problem-driven work (design study)

Design Studies: Lessons learned after 21 of them

• definitions

9-stage framework

• 32 pitfalls

and how to avoid them


Attribute types

• visualization vs computer graphics
– geometry is design decision

Ordering Direction

→ Sequential → Diverging → Cyclic

Three major datatypes

Three major datatypes

Three major datatypes

Three major datatypes

Dataset Types

Tables

Networks

Fields (Continuous)

Geometry (Spatial)

• {action, target} pairs
– discover distribution
– compare trends
– locate outliers
– browse topology

Trends

A C T R I B U T E S

Why?

How?

What?

Why is validation difficult?
• different ways to get it wrong at each level

Why is validation difficult?
• solution: use methods from different fields at each level

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Why is validation difficult?
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What?

Why?

How?
Derive

• don’t necessarily just draw what you’re given!
  – decide what the right thing to show is
  – create it with a good skeleton

Further reading

  – Group: Interactive Visualizations
  – Group: J. Phoebe D. Knierim


Visual encoding

• analyze idiom structure

Definitions: Marks and channels

• marks
  – geometric primitives

• channels
  – control appearance of marks

• channel properties
different types of information that can be mapped to human perceptual systems.

Definitions: Marks and channels

• marks
  – geometric primitives

• channels
  – control appearance of marks

Visual encoding

• analyze idiom structure as combination of marks and channels

Further reading

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Visual encoding

• analyze idiom structure

Definitions: Marks and channels

• marks
  – geometric primitives

• channels
  – control appearance of marks

• channel properties
different types of information that can be mapped to human perceptual systems.
### Visual encoding
- Analyze idiom structure as combination of marks and channels

1. Vertical position
2. Horizontal position
3. Color hue

#### Popout
- Find the red dot
  - How long does it take?

### Channels: Rankings
- Position on common scale
- Spatial region
- Color hue
- Size
- Area
- Depth (3D position)
- Volume (3D size)
- Tilt/angle
- Magnitude

### Separability vs. Integrality
- Fully separable
- Some interference
- Some/significant interference
- Major interference

1. 2 groups each
2. 2 groups each
3. 3 groups total: integral area
4. 4 groups total: integral base

### Popout
- Find the red dot
  - How long does it take?
Arrange Tables
- Tilt/angle
- Rectilinear
- Separate
- Dense

Channels:
- Parallel
- Ordered

Idiom: bar chart
- one key, one value
- data
- 1 categ attrib, 1 quant attrib
- mark: lines
- channels
- length to value (proximity, shadow direction,...)

Visualize and analyze: data
Express Values
Separate, Order, Align Regions
Axis Orientation
Layout Density

• arrangement: fixed and ordered
- many channels
- same values as other
- tasks
- find trend
- generalize marks emphasize ordering of items along key axes
- by explicitly showing relationship between item and item next

Arrange spatial data
- several to one dozen levels for stacked attrib

Idiom: scatterplot
- express values
- quantitative attributes
- no keys, only values
- data
- 2 quant attribs
- vs
- order and align regions

Idiom: stacked bar chart
- one more key
- data
- 2 categ attrib, 1 quant attrib
- mark: vertical stack of line marks
- channels
- length to value (proximity, shadow direction,...)
- task
- compare, lookup values
- scalability
- dozens to one dozen levels for key attrib

Idiom: line chart / dot plot
- one key, one value
- data
- 2 quant attribs
- mark: points
- channel
- tasks
- scalability
- hundreds of items

Some keys: categorical regions
- regions: contiguous bounded areas distinct from each other
- use space to separate (proximity)
- following expressiveness principle for categorical attributes
- use ordered attribute to order and align regions

Consider: $x$ and $y$?

Session 1
- Arrange Networks and Trees
- Arrange Tables
- Arrange Spatial Data

Session 2
- Arrange Networks and Trees
- Arrange Tables
- Arrange Spatial Data

Visualization Analysis & Design, Half-Day Tutorial
- Munzner, Thomas.
- Visualization Analysis and Design.
**Idiom: similarity-clustered streamlines**

- **data**
  - 3D vector field
- **derived data** (from field)
  - streamline trajectory particle will follow
- **derived data** (per streamline)
  - curvature, torsion, texture flow
  - sign/aggregate complex weighted combination
  - compute cluster hierarchy across all signatures
  - encode color and opacity by cluster
- **tasks**
  - find features, query shape
  - scalability
    - millions of samples, hundreds of streamlines

**Further reading**

- Chip & Arrange Spatial Data

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**Idiom: sfdp (multi-level force-directed placement)**

- **data**
  - original network
  - derived cluster hierarchy step it
- **considerations**
  - better algorithm for same encoding technique
  - some fundamental use of space
  - hierarchy and for algorithm speed/quality but not shown explicitly
- **scability**
  - nodes, edges: IK-10K
  - hardball problem still hits eventually

**Further reading**

- Chip & Arrange Spatial Data

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**Idiom: adjacency matrix view**

- **data:** network
- **transform:** into same data/encoding as heatmap
- **derived data:** table from network
  - 1-quant attribute
  - weighted edge between nodes
  - 2- to-3D constraint: node list x 2
- **visual encoding**
  - cell shows presence/absence of edge
  - **scability**
    - IK nodes, IM edges

**Further reading**

- Chip & Arrange Spatial Data

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**Idiom: tree map**

- **data**
  - tree
  - 1-quant attr at leaf nodes
- **encoding**
  - area containment marks for hierarchical structure
- **tasks**
  - query attribute at leaf nodes
  - scalability
    - IM leaf nodes

**Further reading**

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**Idiom: tree map**

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**Further reading**

- Chip & Arrange Spatial Data
Ordered color: Rainbow is poor default

- benefits
  - perceptually unordered
  - perceptually nonlinear

- problems
  - perceptually unordered
  - perceptually nonlinear

Decomposing color

- first rule of color: do not talk about color!
  - color is confusing if treated as monolithic

- decompose into three channels
  - ordered can show magnitude
    - luminance
    - saturation
    - categorical can show identity
    - hue

- benefits
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  - perceptually nonlinear

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Color Encoding

- Bivariate
  - hue
  - saturation

- Categorical
  - luminance

Luminance

- need luminance for edge detection

  - fine-grained detail only visible through luminance contrast

  - legible text requires luminance contrast!

  - HLS better than RGB for encoding but beware
    - L-lightness = L* luminance

Luminance

- need luminance for edge detection

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  - HLS better than RGB for encoding but beware
    - L-lightness = L* luminance

Categorical color: Discriminability constraints

- noncontiguous small regions of color: only 6-12 bins

- problems
  - perceptually unordered
  - perceptually nonlinear

- benefits
  - fine-grained structure visible and nameable

- alternatives
  - large-scale structure: fewer hues

Vinids / Magma

- monotonically increasing luminance, perceptually uniform

  - colorful, colourblind-safe

  - R, python, DJ

Color maps

- Sequential
  - ordered
  - diverging

- Categorical
  - ordered
  - sequential
  - diverging

- Diverging
  - with care if more than two levels (binary)

- Use with care if more than two levels (binary)!
More information

• this tutorial
  http://www.cs.ubc.ca/~tmm/talks.html#halfdaycourse20

• book
  http://www.cs.ubc.ca/~tmm/vadbook
  – 20% promo code for book+ebook combo: HVN17
  – Illustration acknowledgement: Eamonn Maguire

• full courses, papers, videos, software, talks
  http://www.cs.ubc.ca/group/infovis
  http://www.cs.ubc.ca/~tmm

Visualization Analysis and Design. Munzner.
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