Frameworks/Models
Lecture 5 CPSC 533C, Fall 2004
27 Sep 2004
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Readings
The Structure of the Information Visualization Design Space Stuart Card and Jock Mackinlay, Proc. MAVIS 07
The Eyes Have It: A Task by Data Type Taxonomy for Information Visualizations Ben Shneiderman, Proc. 1996 IEEE Visual Languages, also Maryland HICIL TR 96–13

Frameworks
Shneiderman
- Data, Tasks
Mackinlay/Card/(Bertin)
- Data Types, Marks, Retinal Attributes (incl Position)
Stolte/Tang/Hanrahan, (Wilkinson)
- Table Algebra <-- Visual Interface
Hanrahan, Tony/Moeller
- Data/Conceptual Models

Visual Language is a Sign System
Image perceived as set of signs
Sender encodes information in these signs
Receiver decodes information from these signs

Visualization Big Picture

Mapping
input
- data semantics
  - use domain knowledge
output
- visual encoding
  - visual/graphical/perceptual/retinal
  - channels/attributes/dimensions/variables
    - use human perception
processing
- algorithms
  - handle computational constraints
Bertin: Semiology of Graphics

- geometric primitives: marks
- points, lines, areas, volumes
- attributes: visual/retinal variables
- parameters control mark appearance
- separable channels flowing from retina to brain
- \([x,y]\): position
- \([z]\):
  - size
  - greyscale
  - color
  - texture
  - orientation
  - shape

Design Space = Visual Metaphors

Data Types

- continuous (quantitative)
  - 10 inches, 17 inches, 23 inches
- ordered (ordinal)
  - small, medium, large
  - days: Sun, Mon, Tue, Wed, ...
- categorical (nominal)
  - apples, oranges, bananas

More Data Types: Stevens

- interval: 0 location arbitrary
  - time: seconds, minutes
- ratio: 0 fixed
  - physical measurements: Kelvin temp

Channel ranking varies by data type

- spatial position best for all types
Mackinlay, Card

Data Variables
- 1D, 2D, 3D, 4D, 5D, etc

Data Types
- nominal, ordered, quantitative

Marks
- point, line, area, surface, volume
- geometric primitives

Retinal Properties
- size, brightness, color, texture, orientation, shape...
- parameters that control the appearance of geometric primitives
- separable channels of information flowing from retina to brain

Closest thing to central dogma we’ve got

Shneiderman’s Data+Tasks Taxonomy

Data
- 1D, 2D, 3D, temporal, nD, trees, networks
- text and documents (Hanshagen)

Tasks
- Overview, Zoom, Filter, Details-on-demand,
  - Relate, History, Extract

data alone not enough: what do you need to do?

[Shneiderman, The Eyes Have It: A Task by Data Type Taxonomy for Information Visualizations]

Data Models vs. Conceptual Models

data model: mathematical abstraction
- set with operations
- e.g. integers or floats with *,+

conceptual model: mental construction
- includes semantics, support data
- e.g. navigating through city using landmarks

Models Example

from data model
- 17, 25, –4, 28.6
  - (floats)
using conceptual model
  - (temperature)
to data type
- burned vs. not burned (N)
- hot, warm, cold (O)
- continuous to 4 sig figures (Q)

using task
- making toast
- classifying showers
- finding anomalies in local weather patterns

Time

2D+T vs. 3D
- same or different? depends on POV
  - time as input data?
  - time as visual encoding?

same
- time just one kind of abstract input dimension

different
- input semantics
- visual encoding: spatial position vs. temporal change

Processing might be different
- e.g. interpolate differently across timesteps than across spatial position

Polaris

infovis spreadsheet

table cell
- not just numbers: graphical elements
- wide range of retinal variables and marks

table algebra ↔ interactive interface
- formal language
  - extends Wilkinson
Mackinlay’s Expressiveness Criteria

Expressiveness
A set of facts is expressible in a visual language if the sentences (i.e., the visualizations) in the language express all the facts in the set of data, and only the facts in the data.

Expresses Facts Not in the Data
A length is interpreted as a quantitative value; · Length says something untrue about N data

Mackinlay’s Criteria 2
Effectiveness
A visualization is more effective than another visualization if the information conveyed by one visualization is more readily perceived than the information in the other visualization.
The subject of the next lecture.

Automatic Design
Mackinlay, APT
Roth et al, Sage/Visage

select visualization automatically given data vs. Polaris: user drag and drop exporation

limited set of data, encodings
- scatterplots, bar charts, etc

holy grail
- entire parameter space
Credits

Pat Hanrahan

Torsten Moeller, Melanie Tory
discussions