Frameworks/Models

Lecture 4 CPSC 533C, Spring 2004

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Tamara Munzner

Frameworks

Shneiderman
· Data, Tasks

Mackinlay/Card/Bertin/Stolte/Wilkinson
· Data Types, Marks, Retinal Attributes (incl Position)

Treinish
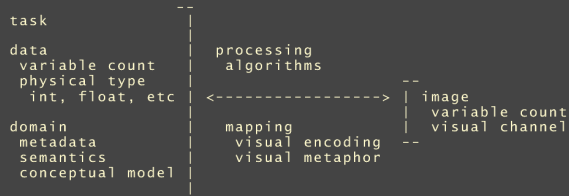· Data, User, Computation, Interaction, Communication, Display

Bertin
Wilkinson
Hanrahan
· Data/Conceptual Models

Visualization Big Picture

```
                   --
task               |
                   |
data               |     processing
 variable count    |      algorithms
 physical type     |                    --
  int, float, etc  | <---------------> | image
                   |                   |   variable count
                   |                   |   visual channel
domain             |     mapping       --
 metadata          |      visual encoding
 semantics         |      visual metaphor
 conceptual model  |
                   --
```

Mapping

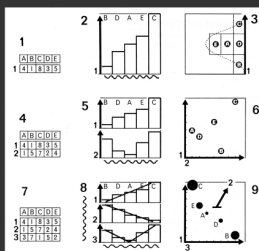input
· data semantics
· use domain knowledge

output
· visual encoding
    visual/graphical/perceptual/retinal
    channels/attributes/dimensions/variables
· use human perception

processing
· algorithms
· handle computational constraints

Design Space = Visual Metaphors

[Bertin, Semiology, 1967]

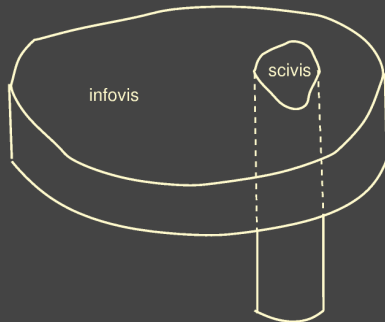# Visual Language is a Sign System

Image perceived as set of signs

Sender encodes information in these signs

Receiver decodes informatio from these signs

Scientific vs Information Visualization

is spatial position given or chosen?

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Shneiderman's Taxonomy

Data
- · 1D, 2D, 3D, Temporal, nD, trees, networks
- · More Data Types (Hanrahan): Text and Documents

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

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

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Mackinlay, Card

Data Types
- · nominal, ordered, quantitative

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

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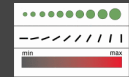- · separable channels of information flowing from retina to brain

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

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Data Types

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

ordered (ordinal)
- · small, medium, large
- · days: Sun, Mon, Tue, Wed, Thu, Fri, Sat

categorical (nominal)
- · apples, oranges, bananas

[graphics.stanford.edu/papers/polaris]

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More Data Types: Stevens

subdivide quantitative further:

interval: 0 location arbitrary
- · time: seconds, minutes

ratio: 0 fixed
- · physical measurements: Kelvin temp

[S.S. Stevens, On the theory of scales of measurements,
Science 103(2684):677-680, 1946]

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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

[Hanrahan, graphics.stanford.edu/courses/
cs448b-04-winter/lectures/encoding/walk005.html]

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Domain

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 anamolies in local weather patterns

Data Models

Discrete	N set relations	topology
	O sorted set	topology
Continuous	fields	manifolds

Data Types: Data Model

Physical Types

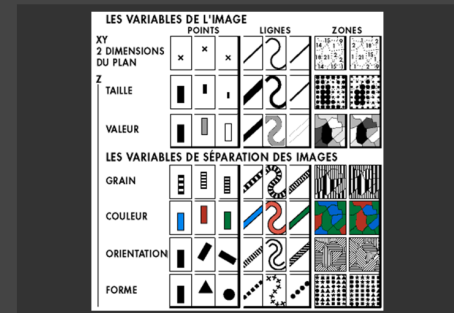- · int, float, double, string, boolean

Number of Variables
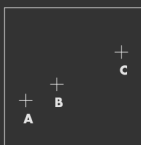- · Treinish: tensor rank

vs. abstract types above

Visual Channels

[Bertin, Graphics, 1983]

[graphics.stanford.edu/courses/cs448b–04–winter/lectures/encoding/walk024.html]
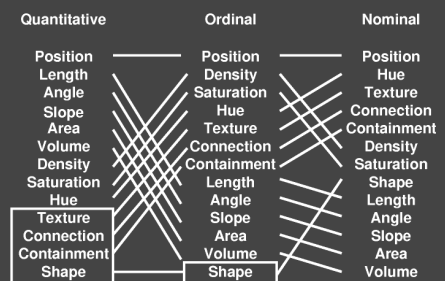
Information in Position

1. A, B, C are distinguishable
2. B is between A and C.
3. BC is twice as long as AB.

"Resemblance, order and proportional are the three signfields in graphics." - Bertin

Channel ranking varies by data type

spatial position best for all types

Quantitative	Ordinal	Nominal
Position	Position	Position
Length	Density	Hue
Angle	Saturation	Texture
Slope	Hue	Connection
Area	Texture	Containment
Volume	Connection	Density
Density	Containment	Saturation
Saturation	Length	Shape
Hue	Angle	Length
Texture	Slope	Angle
Connection	Area	Slope
Containment	Volume	Area
Shape	Shape	Volume

Automatically pick correct visualization

Mackinlay, APT
Roth et al, Sage

limited set of data, encodings

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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

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Credits, More

Pat Hanrahan
[graphics.stanford.edu/courses/cs448b-04-winter/lectures/encoding]
Torsten Moeller, Melanie Tory
· discussions
Vis03 Panel, Theresa-Marie Rhyne
· "Information and Scientific Visualization: Separate but
Equal or Happy Together at Last",
· Melanie Tory
· Matt Ward
· Chris Johnson
· David Laidlaw
J. Bertin
· Semiology of Graphics
Leland Wilkinson
· The Grammar of Graphics