

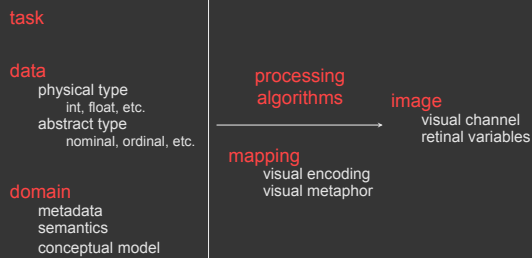
# Visualization Designs

*Maneesh Agrawala*

CS 294-10: Visualization  
Spring 2011

## Last Time: Data and Image Models

### The big picture



[based on slide from Munzner]

### Nominal, ordinal and quantitative

#### N - Nominal (labels)

- Operations: =, ≠

#### O - Ordered

- Operations: =, ≠, <, >, ≤, ≥

#### Q - Interval (Location of zero arbitrary)

- Operations: =, ≠, <, >, ≤, ≥, -
- Can measure distances or spans

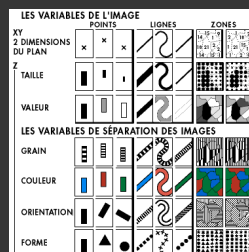
#### Q - Ratio (zero fixed)

- Operations: =, ≠, <, >, ≤, ≥, -, \*
- Can measure ratios or proportions

S. S. Stevens, On the theory of scales of measurements, 1946

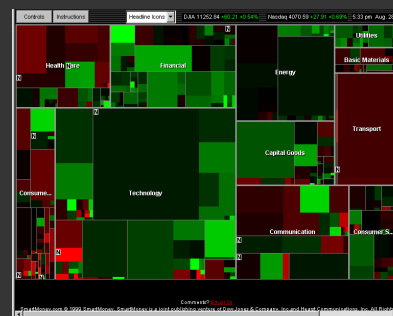
### Visual variables

- Position (x 2)
- Size
- Value
- Texture
- Color
- Orientation
- Shape



Note: Bertin does not consider 3D or time  
Note: Card and Mackinlay extend the number of vars.

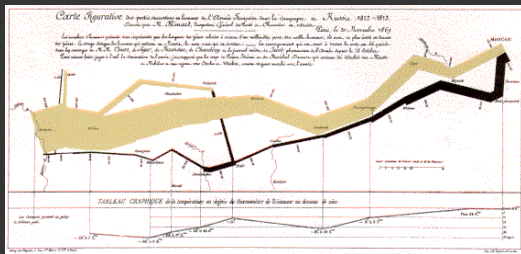
### Wattenberg 1998



<http://www.smartmoney.com/marketmap/>



## Minard 1869: Napoleon's march



Depicts at least 5 quantitative variables  
Any others?

## Automated design

Jock Mackinlay's APT 86



## Combinatorics of encodings

### Challenge:

Pick the best encoding from the exponential number of possibilities  $(n+1)^n$

### Principle of Consistency:

The properties of the image (visual variables) should match the properties of the data.

### Principle of Importance Ordering:

Encode the most important information in the most effective way.

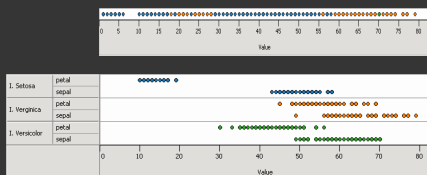
## Mackinlay's expressiveness criteria

### 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.

## Cannot express the facts

A one-to-many ( $1 \rightarrow N$ ) relation cannot be expressed in a single horizontal dot plot because multiple tuples are mapped to the same position



## Expresses facts not in the data

A length is interpreted as a quantitative value;  
∴ Length of bar says something untrue about N data

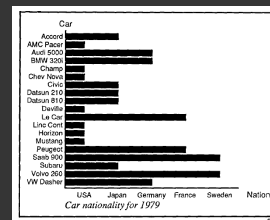


Fig. 11. Incorrect use of a bar chart for the Nation relation. The lengths of the bars suggest an ordering on the vertical axis, as if the USA cars were longer or better than the other cars, which is not true for the Nation relation.

[Mackinlay, APT, 1986]

## Mackinlay's effectiveness criteria

### 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.

### Subject of perception lecture

## Mackinlay's ranking

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

Conjectured *effectiveness* of the encoding

## Mackinlay's design algorithm

- User formally specifies data model and type
- APT searches over design space
  - Tests expressiveness of each visual encoding
  - Generates image for encodings that pass test
  - Tests perceptual effectiveness of resulting image
- Outputs most effective visualization

## Limitations

### Does not cover many visualization techniques

- Bertin and others discuss networks, maps, diagrams
- They do not consider 3D, animation, illustration, photography, ...

### Does not model interaction

## Summary

### Formal specification

- Data model
- Image model
- Encodings mapping data to image

### Choose expressive and effective encodings

- Formal test of expressiveness
- Experimental tests of perceptual effectiveness

## Announcements

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**Auditors, *please* enroll in the class (1 unit, P/NP)**

- Requirements: Come to class and participate (online as well)
- Requirements: Assignment 1

**Class participation requirements**

- Complete readings before class
- In-class discussion
- Post at least 1 discussion substantive comment/question on wiki within a day of each lecture

**All, add yourself to participants page on the wiki**

Class wiki

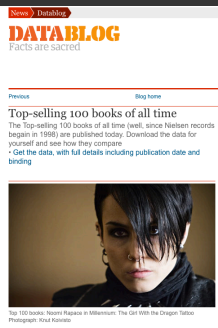
<http://vis.berkeley.edu/courses/cs294-10-sp11/wiki/>

## Announcements

**1/31: No class**

**2/2: Will post Assignment 2: Exploratory Data Analysis**

## Assignment 1: Visualization Design

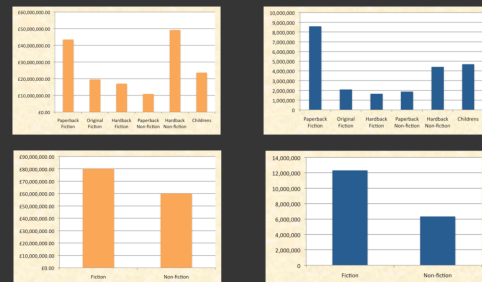


Rank	Title	Author	Year	Sales
1	The Hobbit	J.R.R. Tolkien	1937	940,000,000.00
2	The Lord of the Rings: The Fellowship of the Ring	J.R.R. Tolkien	1954	930,000,000.00
3	The Lord of the Rings: The Two Towers	J.R.R. Tolkien	1954	920,000,000.00
4	The Lord of the Rings: The Return of the King	J.R.R. Tolkien	1954	910,000,000.00
5	The Hobbit	J.R.R. Tolkien	1937	900,000,000.00

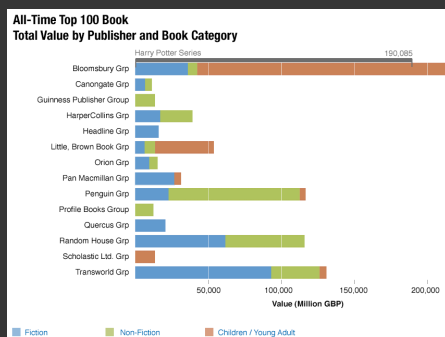
Due by 9am on Jan 26

## Visualization Designs

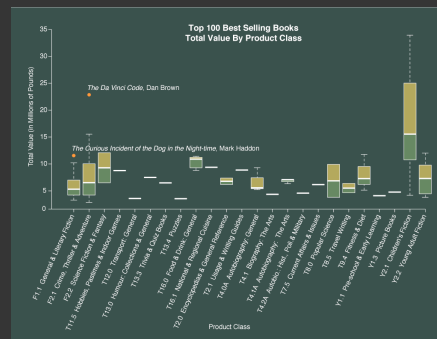
## Bar Charts



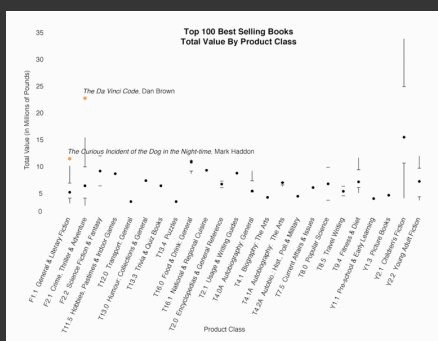
David Wong



Michael Porath



Jessica Voytek

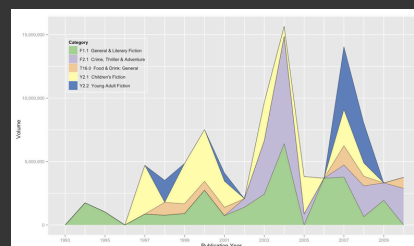


Jessica Voytek



Karl He

## Line Charts



Sergey Karayev

