Spatial Layout

Maneesh Agrawala

CS 448B: Visualization
Fall 2017

Last Time: Using Space Effectively: 2D

Topics

Displaying data in graphs
Selecting aspect ratio
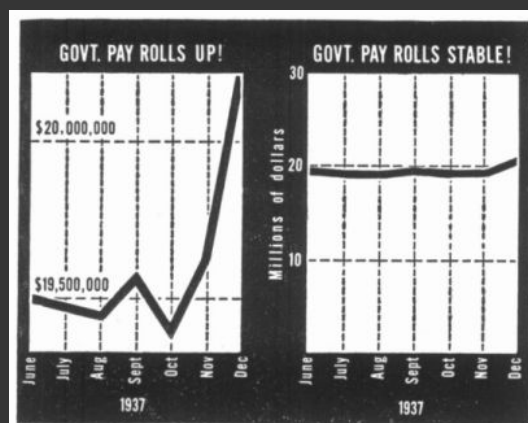**Fitting data and depicting residuals**
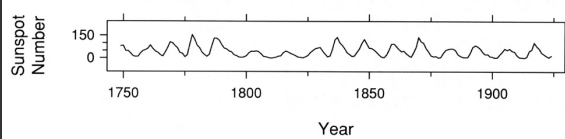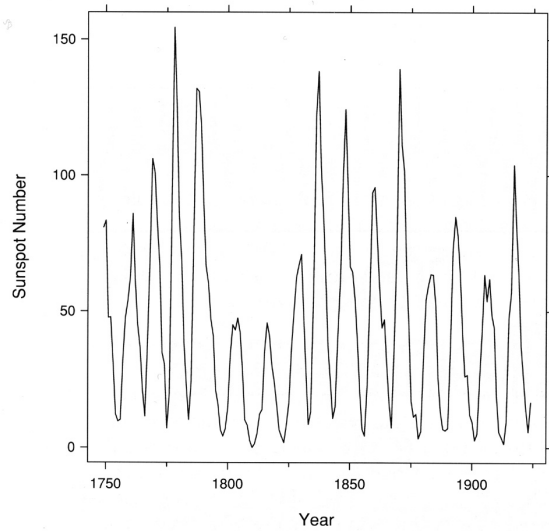**Graphical calculations**
Focus + Context
Cartographic distortion

Effective use of space

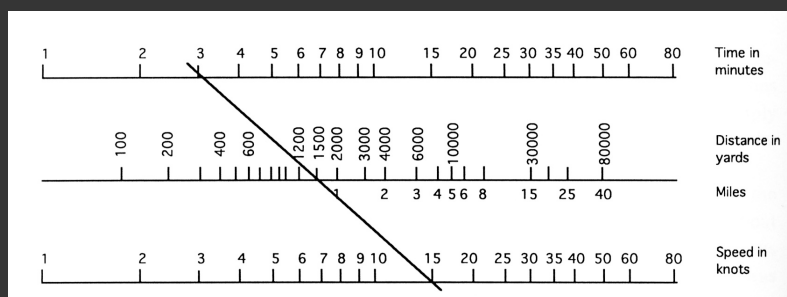**Which graph is better?**

Government payrolls in 1937 [Huff 93]

William S. Cleveland
The Elements of
Graphing Data

Nomograms

1. **Compute in any direction; fix n-1 params and read nth param**

2. **Illustrate sensitivity to perturbation of inputs**

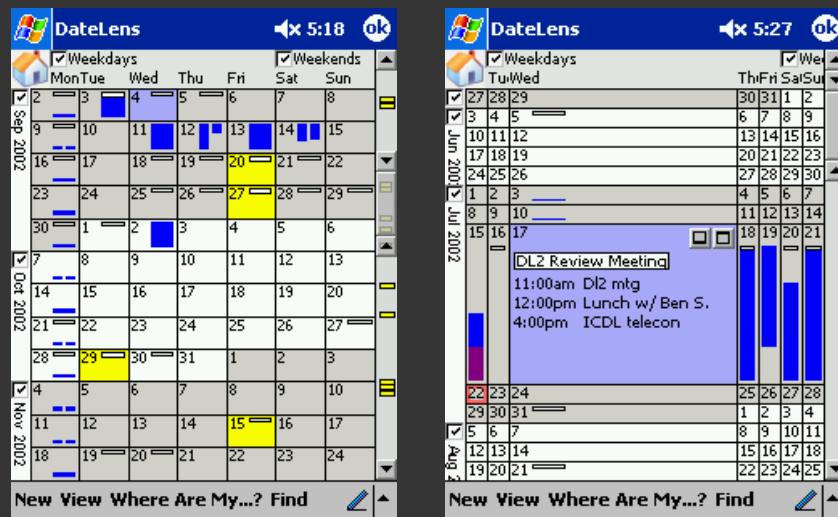3. **Clearly show domain of validity of computation**

Focus + Context

TableLens [Rao & Card 94]

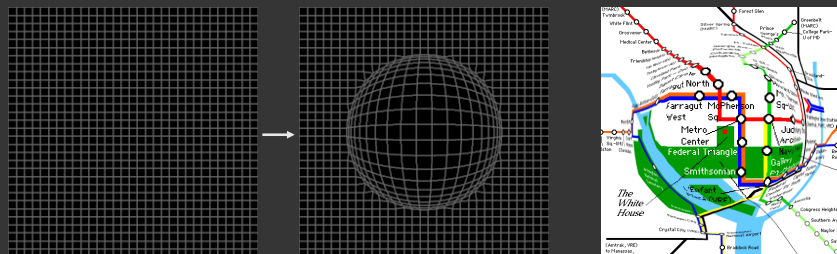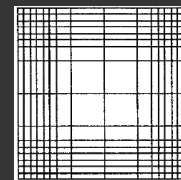# Datelens

[Bederson et al. 04]

Single view detail + context

- **Focus area – local details**
- **De-magnified area – surrounding context**
- **Like a rubber sheet with borders tacked down**

Nonlinear Magnification Infocenter [http://www.cs.indiana.edu/%7Etkeahey/research/nlm/nlm.html]

Bifocal display [Leung and Apperley 94]
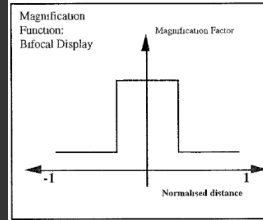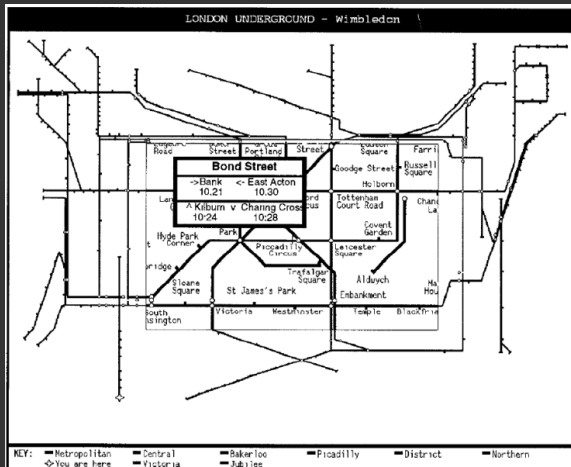
2D distortion

Multifocal display [Leung and Apperley 94]
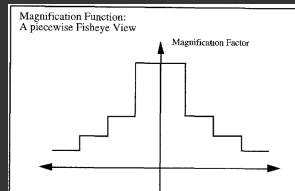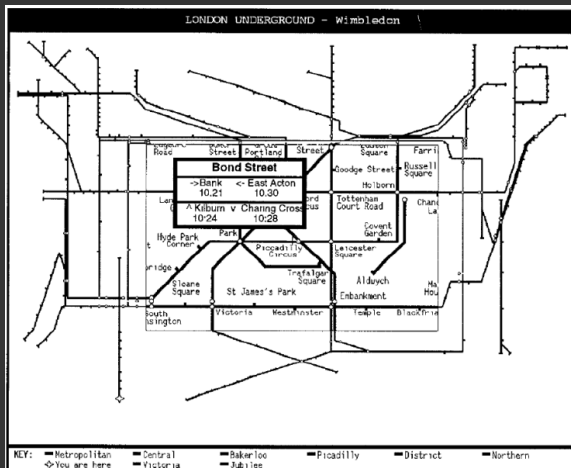
Fisheye [Leung and Apperley 94]

1D   2D

Polar
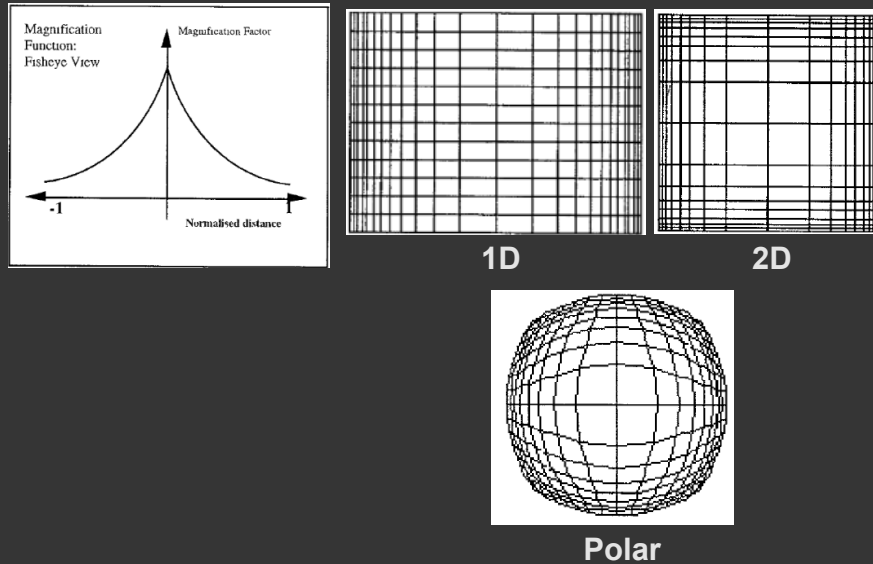
6 types of distortions [Carpendale & Montagnese 01]
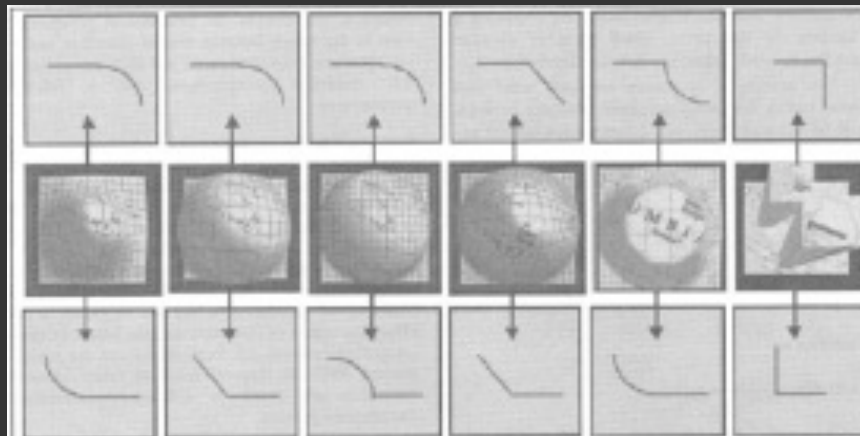
Gaussian, Cosine, Hemisphere, Linear, Inverse Cosine and Manhattan. Top row shows transition from focus to distortion, bottom row from distortion to context.

Perspective allows more context
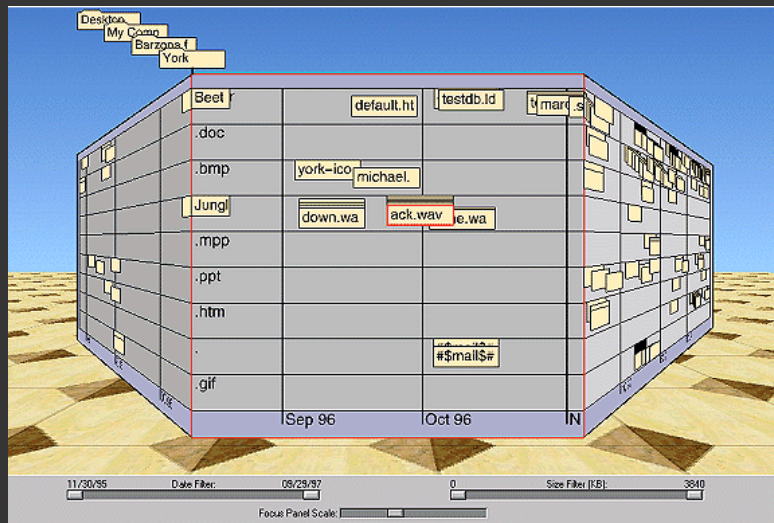
Perspective Wall [Mackinlay et al. 91]

Distortions

Transmogrifiiers [Brosz et al. 13]

Cartograms: Distort areas
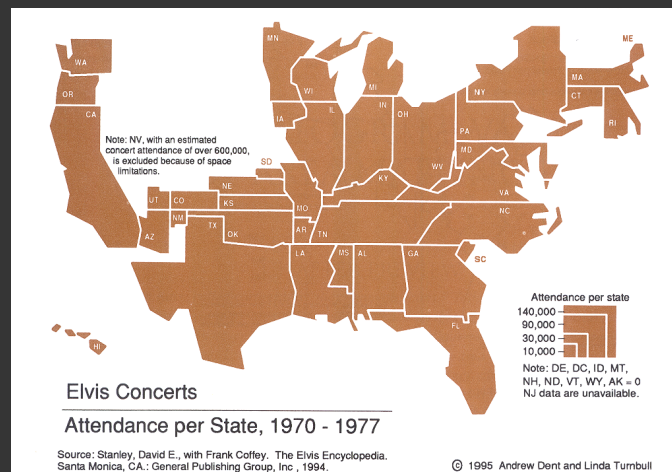
Scale area by data

[From *Cartography*, Dent]

Election 2016 map
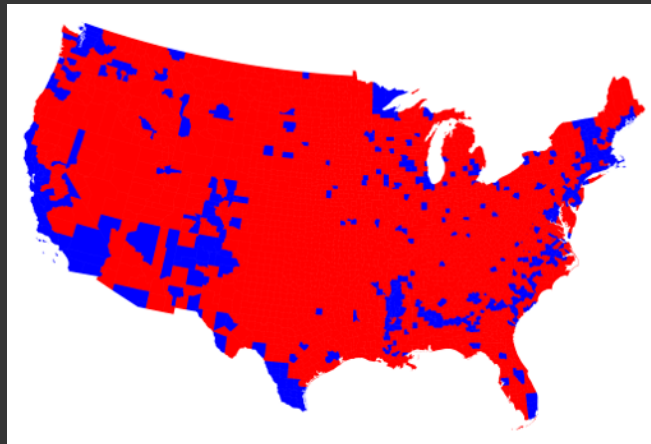
% voted democrat
% voted republican

Election 2016 map

% voted democrat
% voted republican

Election 2016 map

http://www-personal.umich.edu/~mejn/election/
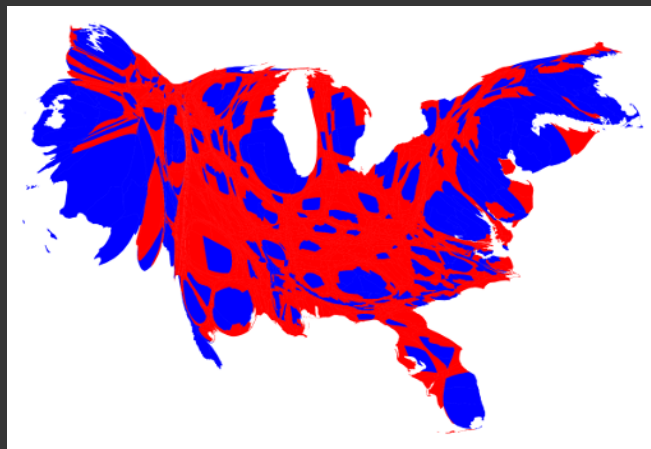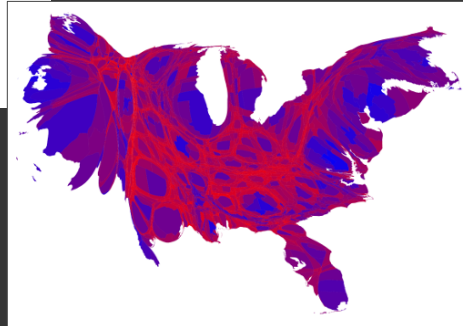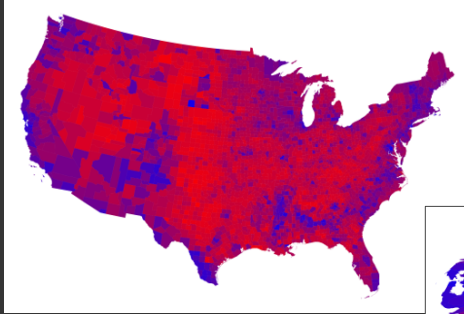
NYT Election 2016 Forecast

Statistical map with shading

MURDER RATES, 1978

FIVE REPRESENTATIVE SHADINGS

- 1.2
- 4.9
- 8.5
- 12.1
- 15.8

RATES PER 100,000 POPULATION
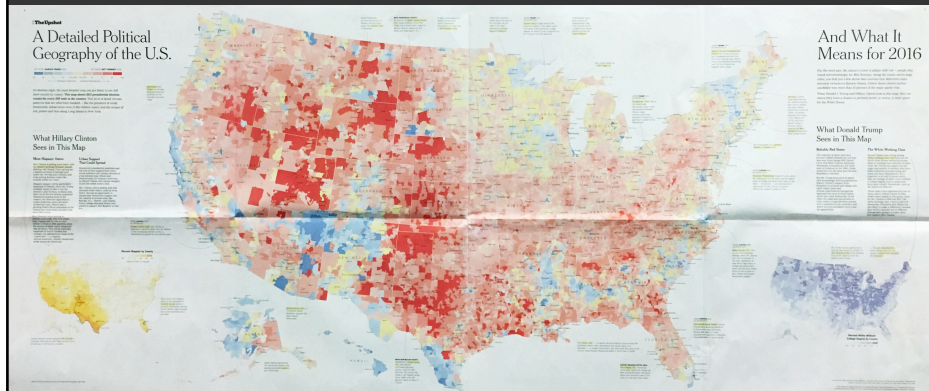
Figure 5. Statistical map with shading.
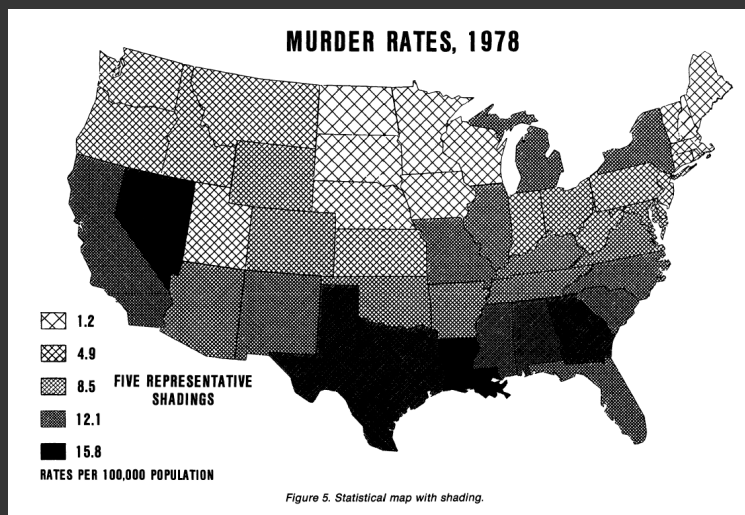
[Cleveland and McGill 84]

Framed rectangle chart

= 0   = 4   = 8   = 12   = 16

MURDER RATES PER 100,000 POPULATION, 1978
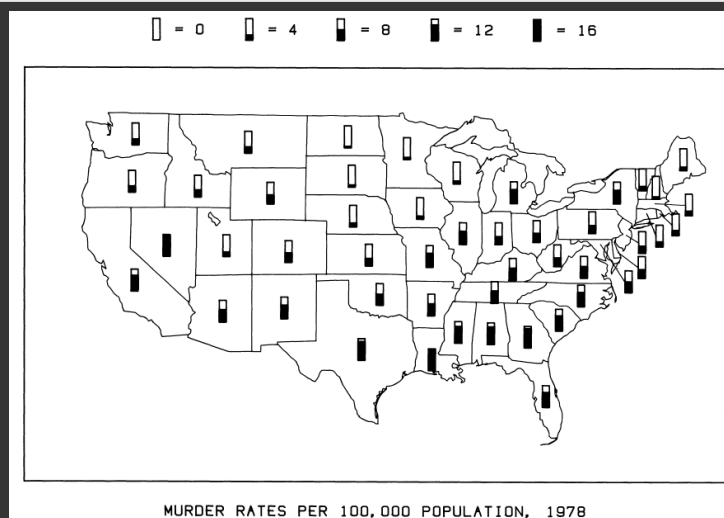
[Cleveland and McGill 84]

Rectangular cartogram
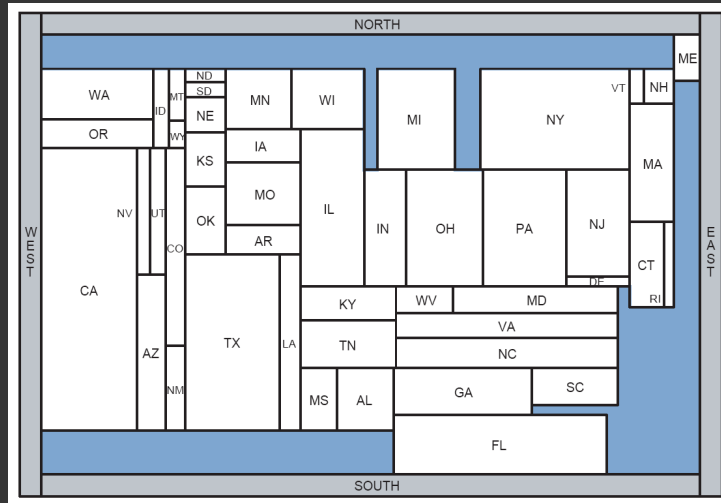
American population [van Kreveld and Speckmann 04]

Rectangular cartogram
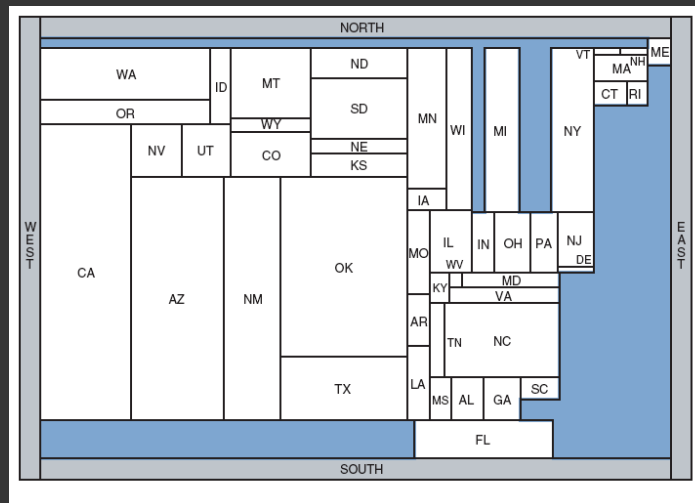
Native American population [van Kreveld and Speckmann 04]

New York Times Election 2004

By Electoral Weight
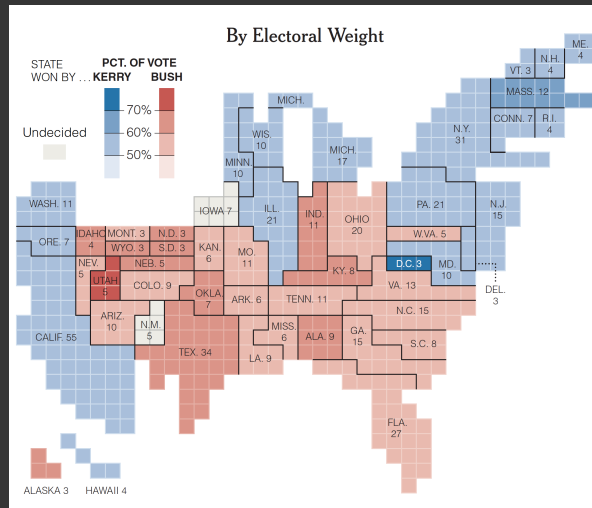
New York Times Election 2016

2016 Electoral Map Forecast
The Upshot's forecast for the presidential race, based on the latest national and state polls.
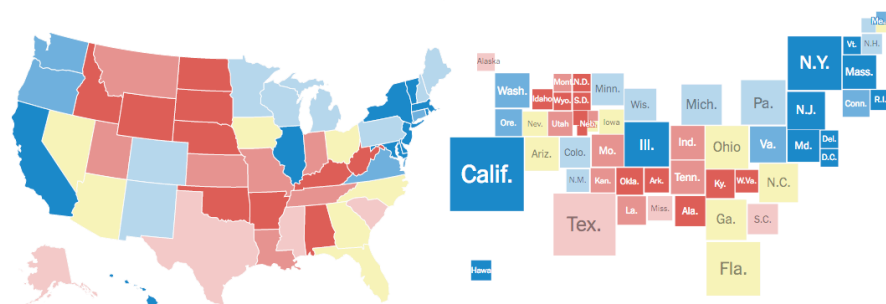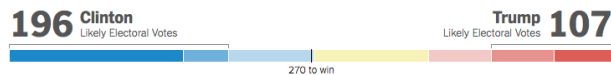
Dorling cartogram

Dorling and Dorling-like Cartograms
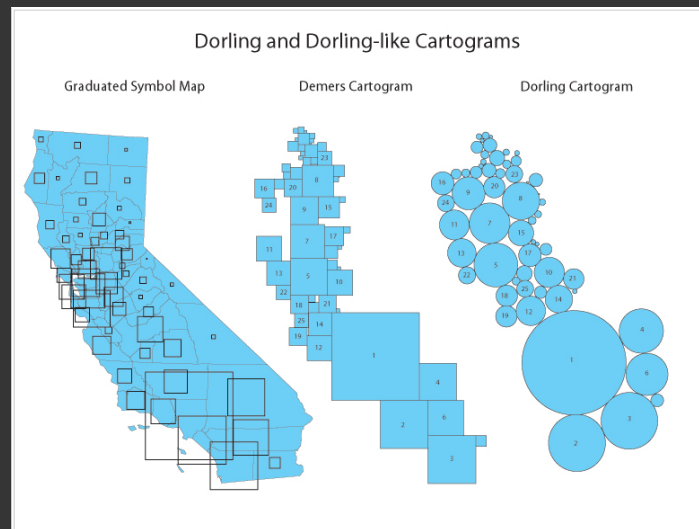
States as nodes in a graph
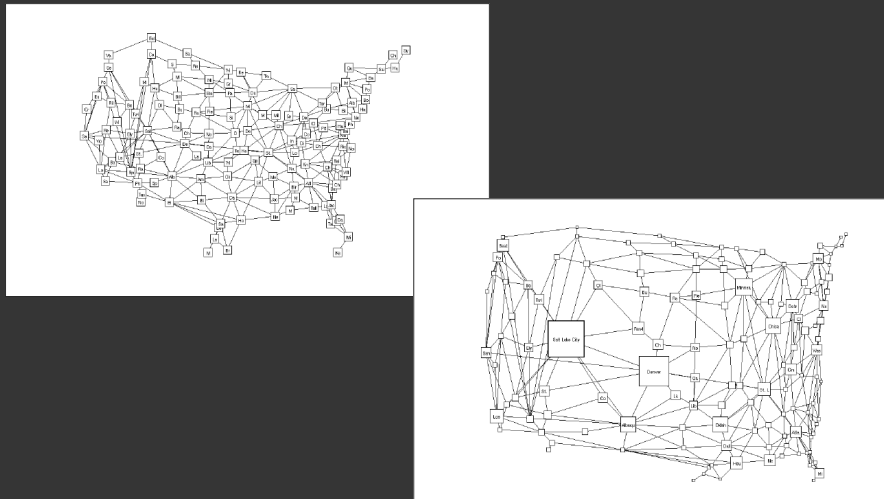
Graphical fisheye views of graphs [Sarkar & Brown 92]

Distorting distances

Figure 1.8 Airlines' view of the United States.
Maps can be scaled to units other than distance. In this case, airline fares are used instead of miles or other linear units.
(Map copyright by the author.)
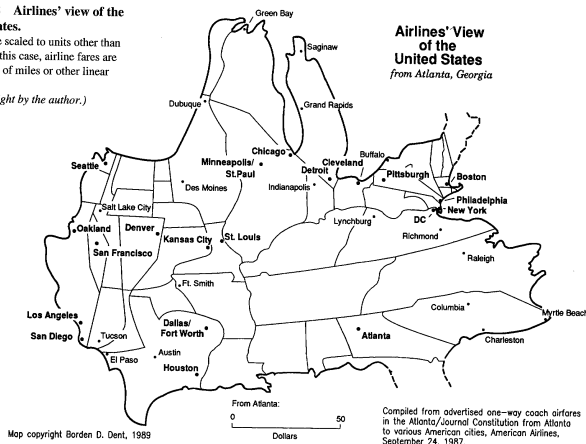
Scale distance by data

[From *Cartography*, Dent]

London underground

http://www.thetube.com/content/history/map.asp

Comparison to geographic map

Distorted
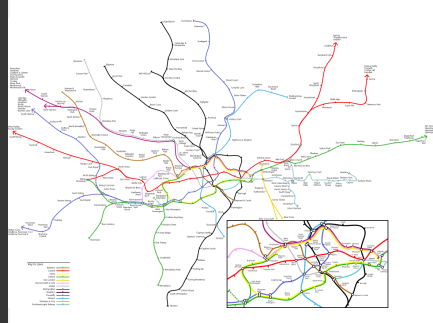
Undistorted

Announcements

Final project

Design new visualization method (e.g. software)
- Pose problem, Implement creative solution
- Design studies/evaluations less common but also possible (talk to us)

Deliverables
- Implementation of solution
- 6-8 page paper in format of conference paper submission
- Project progress presentations

Schedule
- Project proposal: Mon 11/6
- Project progress presentation: 11/13 and 11/15 in class (3-4 min)
- Final poster presentation: 12/6 Location: Lathrop 282
- Final paper: 12/10 11:59pm

Grading
- Groups of up to 3 people, graded individually
- Clearly report responsibilities of each member

Spatial Layout

Example: Timeline label layout
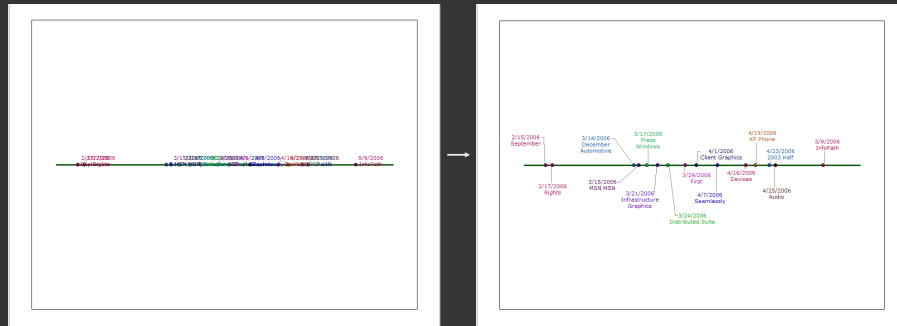
Problem

Input: Set of graphic elements (scene description)

Goal: Select visual attributes for elements

- **Position**
- Orientation
- Size
- Color
- …
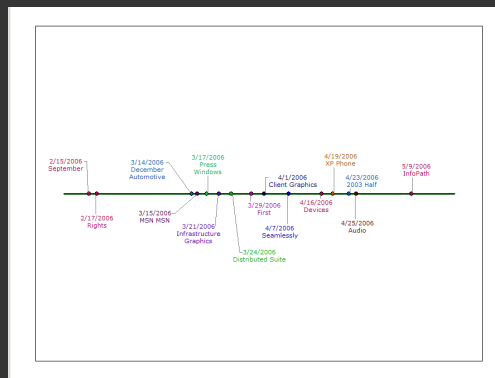
Approaches

Direct rule-based methods

Constraint satisfaction

Optimization

Example-based methods

Direct Rule-Based Methods

Rule-based timeline labeling
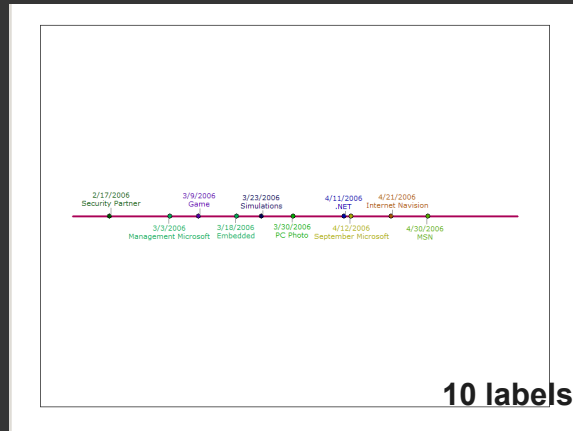
10 labels

- **Alternate above/below line**
- **Center labels with respect to point on line**

Rule-based timeline labeling
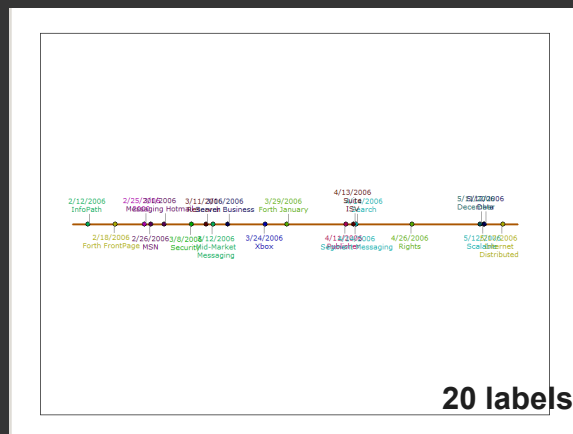
20 labels

- **Alternate above/below line**
- **Center labels with respect to point on line**

Excentric labeling [Fekete & Plaisant 99]

Whitehead
Heller
Hao-wei Hsieh
Erich R. Schneider
Lloyd Rutledge
Chalmers
Martin Hollender
Cathy Marshall
Lennert Sloth
Whitehead
Edouard Belin
Hao-wei Hsieh
Uffe Kock Wiil
Mike Hatzopulous

http://www.cs.umd.edu/hcil/excentric/
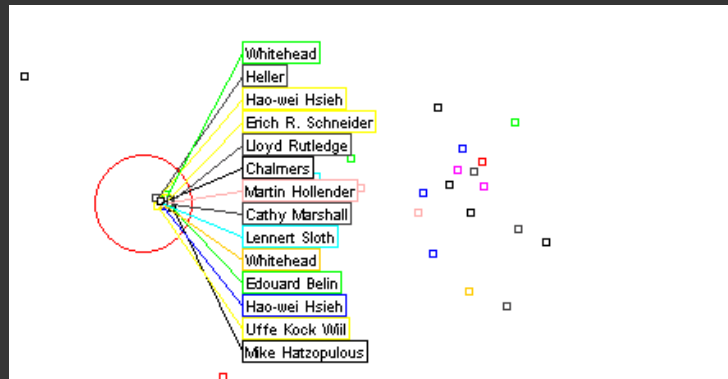
Pros and cons

Pros
- **Designed to run extremely quickly**
- **Simple layout algorithms are easy to code**

Cons
- **Complex layouts require large rule bases with lots of special cases**

Linear Constraint Satisfaction

Network of layout constraints

TITLE ABOVE TEXT1
TITLE FULL PAGE WIDTH
TEXT1 LEFT OF PIC1
CAPTION1 BELOW PIC1
TEXT2 BELOW TEXT1

Constraints

TITLE

TEXT1 — PIC1

TEXT2   CAPTION1

Network

| TITLE |
| TEXT1 | PIC1 |
| CAPTION1 |
| TEXT2 |

| TITLE |
| TEXT1 | PIC1 |
| CAPTION1 |
| TEXT2 |
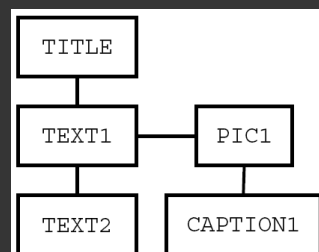
Two possible layouts

[from Lok and Feiner 01]

Constraints as linear equations

rect1

rect2

C1: $rect2.top = rect1.top + rect1.height + 10$
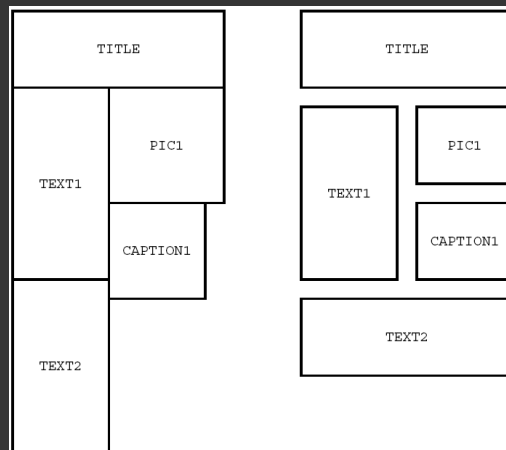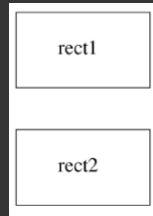
C2: $rect2.height = rect1.height$

C3: $rect2.bottom = rect2.top + rect2.height$

Local propagation
- Set any variable
- Update other variables to maintain constraints

One-way
- Each constraint has 1 output variable
- Update output when any input changes

Multi-way
- Each constraint can be written so that any variable is output
- More complicated to maintain

One-way constraints

rect1

rect2

C1: $rect2.top = rect1.top + rect1.height + 10$

C2: $rect2.height = rect1.height$

C3: $rect2.bottom = rect2.top + rect2.height$

rect1.top ⟶ C1 ⟶ rect2.top

rect1.height ⟶ C2 ⟶ rect2.height

C3 ⟶ rect2.bottom
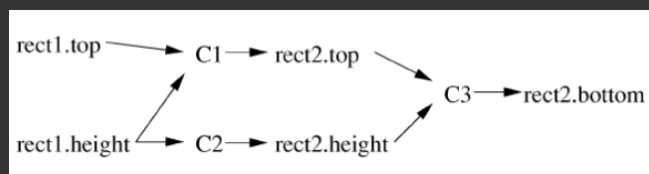
One-way constraints form a directed acyclic graph (DAG). Given the value for any variable we propagate it's value locally through the graph updating the other variable.

Page layout example [Weitzman and Wittenburg 94]

```
(Defrule (Make-Article The-Grammar)
  Article -> Text Text Text Number Image
      0      1    2    3     4     5
  (Author-Of 2 1)
  (Description-Of 4 1)
  (Page-Of 4 1)
  (Image-Of 5 1)
  (article-name 0) = r
  (article-image 0) = 5
  :OUT
  (right-of 1 5)
  (top-aligned 1 5)
  (top-aligned 5 4)
  (spaced-below 2 1)
  (spaced-below 3 2)
)
```
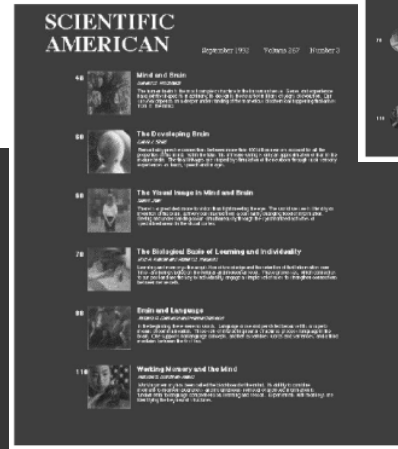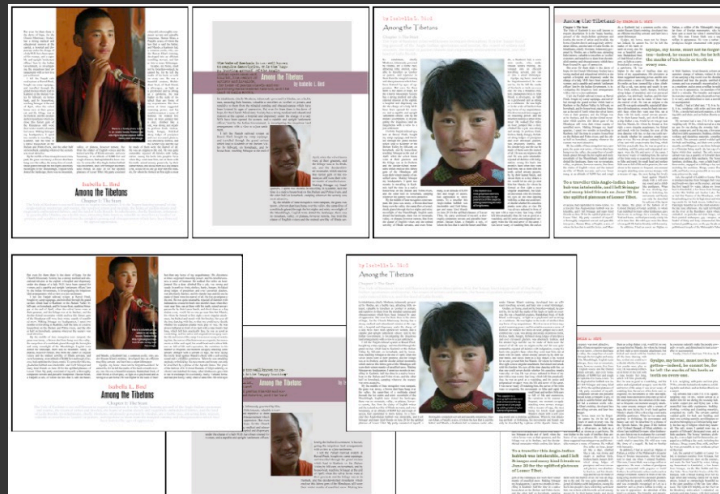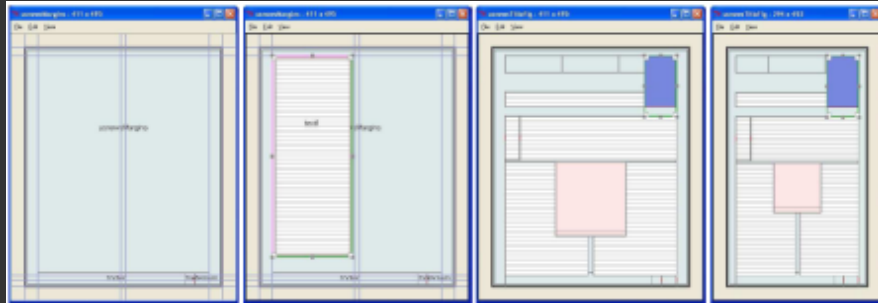

Adaptive document layout [Jacobs 03]

Users authors templates which use one-way constraints to adapt to changes in page size

ADL template authoring [Jacobs 03]

ADAPTIVE GRID~BASED DOCUMENT LAYOUT

CHUCK JACOBS[1]   WILMOT LI[2]   EVAN SCHRIER[2]
DAVID BARGERON[1]   DAVID SALESIN[1,2]

[1]MICROSOFT RESEARCH   [2]UNIVERSITY OF WASHINGTON

Pros and cons

Pros

- **Often run fast (at least one-way constraints)**
- **Constraint solving systems are available online**
- **Can be easier to specify relative layout constraints than to code direct layout algorithm**

Cons

- **Easy to over-constrain the problem**
- **Constraint solving systems can only solve some types of layout problems**
- **Difficult to encode desired layout in terms of mathematical constraints**