Spatial Layout

Maneesh Agrawala

CS 448B: Visualization
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Last Time: Using Space Effectively: 2D
Topics

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

Effective use of space

Which graph is better?

Government payrolls in 1937 [Huff 93]
Transforming data

Residual graph
- Plot vertical distance from best fit curve
- Residual graph shows accuracy of fit

[Cleveland 85]
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

Zooming

Focus + Context

TableLens [Rao & Card 94]

http://www.youtube.com/watch?v=qWqTrRAC52U
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/~tkeahey/research/nlm/nlm.html]
Bifocal display [Leung and Apperley 94]

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

- Magnification Function: Fisheye View
- 1D and 2D Representations
- Polar View

**Nonlinear magnification** [Leung and Apperley 94]

- Magnification Function: Polrifocal Display
- 1D and 2D Representations
- Multifocal View
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]
Uses (and abuses) of distortion

Often more harm than help, unless
- Builds on experience (e.g., perspective wall) and enables a particular task
- Intended to elicit response, capture attention
  - In which case it should draw attention directly to the phenomenon of interest.

Pan and zoom more familiar—and visually stable—than “rubber sheet”

Consider F+C of data rather than view
Transmogrifiers [Brosz et al. 13]

http://www.transmogrifiers.org/

Cartograms: Distort areas

Scale area by data

[From Cartography, Dent]
Election 2012 map

http://www-personal.umich.edu/~mejn/election/

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Statistical map with shading

Figure 8: Statistical map with shading.

[Cleveland and McGill 84]
Framed rectangle chart

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

[Map showing electoral votes by state]

2016 Electoral Map Forecast
The Upshot's forecast for the presidential race, based on the latest national and state polls.
By JOSH KATE and ADAM PICONE 
UPDATED November 2, 2016

196 Clinton Likely Electoral Votes

107 Trump Likely Electoral Votes

Dorling cartogram

Dorling and Dorling-like Cartograms

Graduated Symbol Map
Demers Cartogram
Dorling Cartogram

http://www.ncgia.ucsb.edu/projects/Cartogram_Central/types.html
States as nodes in a graph

Graphical fisheye views of graphs [Sarkar & Brown 92]

Distorting distances

Scale distance by data
[From Cartography, Dent]
London underground

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

Comparison to geographic map

Distorted  Undistorted
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: 11/7
- Project progress presentation: 11/14 in class (3-4 min) slide presentation
- Final poster presentation: 12/9 Location: TBD
- Final paper: 12/12 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

- Alternate above/below line
- Center labels with respect to point on line
Rule-based timeline labeling

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

Excentric labeling [Fekete & Plaisant 99]

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

Constraints

Two possible layouts

[from Lok and Feiner 01]

Constraints as linear equations

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 form a directed acyclic graph (DAG). Given the value for any variable we propagate its value locally through the graph updating the other variable.

\[ \text{C1: rect2.top} = \text{rect1.top} + \text{rect1.height} + 10 \\
\text{C2: rect2.height} = \text{rect1.height} \\
\text{C3: rect2.bottom} = \text{rect2.top} + \text{rect2.height} \]
Adaptive document layout [Jacobs 03]

Users author 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\textsuperscript{1} Wilmot Li\textsuperscript{2} Evan Schrier\textsuperscript{2}
David Barger\textsuperscript{1} David Salesin\textsuperscript{1,2}

\textsuperscript{1}Microsoft Research \textsuperscript{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
Optimization

Demo

[Diagram of a pie chart with various segments labeled]
Layout as optimization

Scene description

- **Geometry**: polygons, bounding boxes, lines, points, etc.
- **Layout parameters**: position, orientation, scale, color, etc.

Large design space of possible layouts

To use optimization we will specify …

- **Initialize/Perturb functions**: Form a layout
- **Penalty function**: Evaluate quality of layout
- .. and find layout that minimizes penalty

Optimization algorithms

There are lots of them:

- line search, Newton’s method, A*, tabu, gradient descent, conjugate gradient, linear programming, quadratic programming, simulated annealing, …

Differences

- Speed
- Memory
- Properties of the solution
- Requirements
Simulated annealing

$\text{currL} \leftarrow \text{Initialize}()$

while(! termination condition)

$\text{newL} \leftarrow \text{Perturb}(\text{currL})$

$\text{currE} \leftarrow \text{Penalty}(\text{currL})$

$\text{newE} \leftarrow \text{Penalty}(\text{newL})$

if($\text{newE} < \text{currE}$ or $(\text{rand}(0,1) < e^{-\Delta E/T})$)

then $\text{currL} \leftarrow \text{newL}$

Decrease($T$)

**Perturb**: Efficiently cover layout design space

**Penalty**: Describes desirable/undesirable layout features

Scene description

- **Geometry**
  - Pie slices
    - anchors for labels
  - Labels
    - bounding boxes