IAT 814
Knowledge Visualization

Reducing complexity: Space

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Space

- Space is our most important encoding.
- We don’t have enough of it.
- How can we use it most effectively?
So much data, so little space: 1

- Huge amounts of data (many items)
- Rich data (many dimensions)
- Heterogeneous data (many sources)
- Patterns and relations across sets
- Occlusion and overplotting
- Visual fragmentation
  - Decoding too many different visual forms
Strategies we have (implicitly) considered so far

- Choose the right data abstractions
- Distribute data across multiple forms and views
  - Cross-cut and slice: **facet**
  - Brushing and linking interactions
- Provide rich interactive techniques
Part of larger set of strategies

- Mitigate overplotting
- Facet appropriately
- Reduce what we need to draw
- Transform the data
Reducing overplotting [Few]

- Reduce size of objects
- Remove fill colour
- Change shape from container (e.g., circle) to non-container (X)
- \textit{Jitter} the data
- Make data objects transparent

- White space challenges vis
- Graphical tricks only go so far.
Facets: Dimensional division

• “splitting” dimensions across linked views
• Small multiples
• Trellis displays
• Scatterplot matrices
Facets: Small multiples

- use the same basic graphic or chart to display difference slices of a data set
- rich, multi-dimensional data without trying to cram all that information into a single, overly-complex chart.
- Singular design reduces decoding effort.

Facets: Small multiples

- Agriculture
- Business services
- Construction
- Education and Health
- Finance
- Government
- Information
- Leisure and hospitality
- Manufacturing
- Mining and Extraction
- Other
- Self-employed
Small multiples
Horizon graphs
Trellis plots
Facet choices

How data are partitioned between views
Basic approaches

- How do we reduce the amount of stuff to draw?
  - Connected with view and facet composition decisions
  - Reduce overplotting

- Reduce the number of data points
  - Item reduction
  - Interaction

- Reduce the number of dimensions
  - Attribute reduction
5 strategies for managing complexity

1. Derive new data elements

2. Manipulate the view
   • Change over time
   • Navigation
   • **Overview first, filter + zoom, details on demand** [Shneiderman]

3. Facet into multiple views

4. Reduce data items and attributes

5. Focus + Context
Manipulating views [Munzner]

- Filter and navigation
  - Leave some things out
- Overviews
  - Sequential/temporal with navigation
  - Separate linked views
- Focus and context
  - Selective filtering
  - Distortion techniques
- Aggregation
  - Merge things together
- Zoom in/out
  - Semantic hierarchy
  - Details on demand
View transformations

• Viewpoint controls
  • Zoom, pan, clip
  • Overview+detail

• Focus+Context
  • Bifocal: Perspective Wall, Document Lens
  • Polyfocal: Table Lens
  • Based on levels of interest: Fish Eye Lens

• Location probes
  • Details on demand
  • Brushing
  • Magic lenses

• Location probes support dimensional slicing/faceting and cutting
So much data, so little space

Scale - Many data sets are too large to visualize on one screen

• May simply be too many cases
• May be too many dimensions
• May only be able to highlight particular cases or particular variables, but viewer’s focus may change from time to time
Common Solution- Scroll/Pan

- larger, virtual screen allows user to move to different areas
  - Requires one or more of
    - Dedicated interaction operation (mouse, touch)
    - Peripheral scroll bars

- Benefits?
- Issues?
Panning and Zooming

• Panning
  • Smooth movement of camera across scene (or scene moves and camera stays still)

• Zooming
  • Geometric: changes the magnification of the objects in a scene
  • Semantic: shows the data at different levels of detail
    • Representation changes according to available pixels

• Useful for changing focal point
Pan and Zoom

How to show a lot of information in a small space?

• Multiple Levels of Resolution
  • The view changes depending on the “distance” from the viewer to the objects

• multiscale-based variable representations
  • Keep a steady overview, make some objects larger while simultaneously shrinking others
Taxonomy

- Zooming: temporal separation
- Overview+detail: spatial separation
- Focus+Context: integrated/embedded

Zooming

• Standard Zooming
  • Get close in to see information in more detail
  • Example: Google earth zooming in

• Intelligent Zooming
  • Show semantically relevant information out of proportion
  • Example: speed-dependent zooming, Igarishi & Hinkley
  • OrthoZoom 1D

• Semantic Zooming
  • Zooming shows the data at different levels of semantic detail,
  • Example: Multiscale, Pad++ and Piccolo projects
Space-Scale Diagrams

- Reasoning about navigation and trajectories
- Horizontal axis is standard, vertical is scale

[Space-Scale Diagrams: Understanding Multiscale Interfaces. George Furnas and Ben Bederson, Proc SIGCHI '95.]
Space-Scale Diagrams

- User has a fixed-sized viewing window
- Moving it through 3D space yields all possible sequences of pan & zoom

[Space-Scale Diagrams: Understanding Multiscale Interfaces. George Furnas and Ben Bederson, Proc SIGCHI '95.]
Space-Scale Diagrams

- If you move the origin of the 2D plane, the properties of the original 2D picture do not change.

- Therefore, the absolute angles between the rays should not be assigned any meaning.

[Space-Scale Diagrams: Understanding Multiscale Interfaces. George Furnas and Ben Bederson, Proc SIGCHI '95.]
Space-Scale Diagrams

- We can think of this in terms of 1D
- When zoomed out, you can see wider set of points

[Space-Scale Diagrams: Understanding Multiscale Interfaces. George Furnas and Ben Bederson, Proc SIGCHI '95.]
Pan-Zoom Trajectories

[Space-Scale Diagrams: Understanding Multiscale Interfaces. George Furnas and Ben Bederson, Proc SIGCHI '95.]
Shortest path
What about panning and zooming at the same time?

- Panning is linear
- Zooming is logarithmic
- The two effects interact
  - If you compute the two separately and run them in parallel you get problems
  - When zooming in, things go exponentially fast
  - Panning can’t keep up
    - The target “runs away” out of view

[Space-Scale Diagrams: Understanding Multiscale Interfaces. George Furnas and Ben Bederson, Proc SIGCHI '95.]
How to Pan While Zooming?
How to Pan While Zooming?
Smooth and Efficient Zooming

- Parametric space,
  - \( u = \text{pan}, \ w = \text{zoom} \)

- Developed algorithm for optimal paths through the space

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Pad++

- Infinitely zoomable user interface (ZUI)
- Can get infinitely close to the surface too
- Navigate by panning and zooming
- Pan:
  - move around on the plane
- Zoom:
  - move closer to and farther from the plane

Zoomable UIs

Panning across objects in two directions.

Zooming out for an overview.

Zooming in for greater detail.
Important Concepts

- Portals
- Lenses
- Sticky objects
- Semantic zooming
Portals

- Views onto another place in the world
- Implemented typically as separate rectangular region
- Zooming, panning, I/O all work independently in there
- Can be used to create overviews or focus regions
Lenses

- Rectangular regions/objects that can be moved around on display
- Objects that alter the appearance and behavior of objects seen through them
Sticky Objects

- Objects in the world that do not respond to the basic zoom/pan interface physics
- Objects are “stuck” to the display
  - They never change position
  - They never change size
Navigation in Pad++

• How to keep from getting lost?
  • Animate the traversal from one object to another using “hyperlinks”
    • If the target is more than one screen away, zoom out, pan over, and zoom back in
  • Goal: help viewer maintain context
The Role of Portals

- All this panning and zooming can get confusing (maybe even dizzying)
- Portals allow for zooming a small piece of the dataset while keeping everything else in the same position
  - Pad++ is one big stretchy sheet
  - A portal is more like a special window into a piece of the sheet
  - That window behaves independently of the rest
Standard vs. Semantic Zooming

• Geometric (standard) zooming:
  • The view depends on the physical properties of what is being viewed

• Semantic Zooming:
  • When zooming away, instead of seeing a scaled-down version of an object, see a different representation
  • The representation shown depends on the meaning to be imparted.
Semantic Zooming

- Zooming that is not simply a change in size or scale like simple magnification
- Objects change fundamental appearance/presence at different zoom levels
- Zooming is like step function with boundaries where a semantic transition takes place
Concept of Semantic Zoom

- Infinitely scalable painting program
  - close in, see flecks of paint
  - farther away, see paint strokes
  - farther still, see the holistic impression of the painting
  - farther still, see the artist sitting at the easel
Examples of Semantic Zoom

• Information Maps
  • zoom into restaurant
    • see the interior
    • see what is served there
  • maybe zoom based on price instead!
    • see expensive restaurants first
    • keep zooming till you get to your price range

• Browsing an information service
  • Charge user successively higher rates for successively more detailed information
Speed-dependent Zooming
by Igarashi & Hinkley 2000

http://www-ui.is.s.u-tokyo.ac.jp/~takeo/video/autozoom.mov
http://www-ui.is.s.u-tokyo.ac.jp/~takeo/java/autozoom/
autozoom.htm
View Infinity

Model-based discrete semantic zoom

*View Infinity: A Zoomable Interface for Feature-Oriented Software Development*
OrthoZoom: 1D Multiscale Navigation

- Control area itself larger than representation allows
- Zoom factor is orthogonal cursor-slider distance
- Pan with slider
- Zoom with horizontal movement
- Improves target finding in very large 1D spaces
- Uses levels of data structure to determine “snappable” points
- Demo

Panning and Zooming

- Is it actually useful?
  - Is it better to facet into multiple juxtaposed views?

- Would keeping a separate global overview help with navigation?
  - The research literature suggests overview+detail is usually better than pan & zoom.

- Navigation alone can’t maintain overview
  - Have to hold overview in working memory
Overviews

- Helps present overall patterns
- Assists user with navigation and search
- Orients activities

- Strategies: filter and aggregate
  - Simple: geometric zoom out
  - Complex: aggregation

- Methods
  - Temporal (navigation)
  - Separate views
  - Embedded: focus + context
Overview + Detail

• Overview + Detail displays can be combined via either time or space
  • Time - Alternate between overview and details sequentially in same place
  • Space - Use different portions of screen to show overview and details

• Big question in Vis:
  • Develop visualization and interface techniques to allow flexible alternation
Objective

- Allow viewer to examine cases and/or variables in detail while still maintaining context of those details in the larger whole
- Concession
  - You simply can’t show everything at once
- Be flexible, facilitate a variety of user tasks
- Visualization + Navigation
You are here
Managing detail

• Single window with horizontal and vertical panning
  • Works only when image/space is not too much larger than the window
Single Window

- Single view with Selectable Zoom area
  - Selected zone is new view
  - Magnification and adjustment can follow
  - Context switch disorienting
Single Window

- Main + mini-map
- Sometimes the *Overview* gets the most space
  - Depends on the user’s familiarity with the object of interest
  - Panning in one affects the other
- Could be extended to 3 or more levels
- Issue: How big are different views and where do they go?
Overview + Detail

K. Hornbaek et al., Navigation patterns and Usability of Zoomable User Interfaces with and without an Overview, ACM TOCHI, 9(4), December 2002
Overview + Detail

- A study on integrating Overview + Detail on a Map search task
  - Incorporating panning & zooming as well.
  - They note that panning & zooming does not do well in most studies.
- Results seem to be
  - Subjectively, users prefer to have a linked overview
  - But they aren’t necessarily faster or more effective using it
  - Well-constructed representation of the underlying data may be more important.
- More research needed as each study seems to turn up different results, sensitive to underlying test set.

K. Hornbaek et al., Navigation patterns and Usability of Zoomable User Interfaces with and without an Overview, ACM TOCHI, 9(4), December 2002
Lens Technique

- Enlarged image floats over the overview
- Neighbor objects obscured by the detail view
Overviews

- How to deal with approximate view?
- Reduce the data elements
  - Eliminate
  - Sample
  - Aggregate

- Reduce the visual representation
  - Need to render to sub-pixel resolution
  - Accumulate visual contributions per pixel
Focus + Context

- **Focus + Context** is an InfoVis term:
  - Present the Detail and the overview in the same window

- Integrate detailed view (focus) in the larger space (overview)

- Maintain continuity
Figure 4.21 The organisation tree of a company
Figure 4.22  Showing the ‘distance’ of each node from the focus of attention
Figure 4.23  The context defined by setting an upper threshold of unity for distance from a focus
Figure 4.24: Example of a display that might be associated with the focus and context defined in Figure 4.23.
Figure 4.25  Each node in the organisation tree has been assigned an *a priori* importance (API)
Figure 4.26 Nodal values of degree of interest (=API – D). Setting a lower limit of 6 for DoI identifies the nodes within the shaded region.
Focus + Context Methods

- Selective Filtering /aggregation (elision)
- Geometric distortion

- Degree of interest (DOI)

- Benefits and costs
Degree of Interest (DOI)

- Degree of interest used to apply view distortions $I(x) \rightarrow D(x,y)$
  - $I$ : interest
  - $D$: distance (semantic or spatial)
  - $x$: data element
  - $y$ : current focus

- DOI for selective presentation vs for distortion
- Identified by explicit selection or inferred by interaction
- Single vs multiple foci

Focus+Context: Filtering/aggregation

- **SpaceTree**
  - Selective filtering – elision

- Semantic zooming / aggregation
Focus + Context: 3D surfaces

- Bifocal display
- “Wraps” view onto a 3D surface then flattens perspective view onto 2D plane

Focus+Context: 3D wrapping

- Moves focus point closer in depth to eye
- Perspective Wall

Figure 5. The Perspective Wall (Mackinlay et al. 1991).
F+C Distortion: Fisheye

- Magnify an area of interest without obscuring its neighboring unmagnified imagery
- Low-level details elided
- Invented by Furnas, 1991
Fisheye Terminology

- Focal point
- Distance from focus
- Level of detail
- Degree of interest function (DOI)
Level of Detail

- A number determines the quantity of visual info you are going to draw for one data element
- In maps: The quantity of imagery that fits in X pixels
DoI Function

- Can take on various forms
  - Continuous - Smooth interpolation away from focus
  - Filtering - Past a certain point, objects disappear
  - Step - Levels or regions dictating rendering  $0<x<0.3$ all same, $0.3<x<0.6$ all same
  - Semantic changes - Objects change rendering at different levels
Examples: 1D

- **Fisheye Menus – Bederson**
  - Dynamically change size of menu item & provide focus area around the pointer
  - Items near cursor displayed at full size
  - Items further away on either side are smaller
  - Uses a distortion function so items will always fill menu
  - Efficient mechanism for long menus
  - Need to “Lock Focus” to hit nearby targets (on right)
Elastic Presentation Space
2D Hyperbolic Trees

- Fisheye effect from hyperbolic geometry

Distortion challenges

- Unsuitable for relative spatial judgments (length, location)
  - Graphs (topology) least problematic?
- Distortion must be tracked
  - Constrained and predictable
- Visual communication of distortion
  - Grid lines, shading, highlighting
- Target acquisition is more difficult (items move away!)
- Mixed results compared to separate views, temporal navigation
- Fisheye concerns
  - What is shown (selective filtering, aggregation)
  - How it is shown (distortion one strategy for spatial representation)

Semantic fisheye

SpectraVis: Information Visualization for Supernova Spectra