Large Scale Information Visualization

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Interaction

A major portion of these slides come from John Stasko's course slides
What is Interaction?

- From Google: Reciprocal action between a human and a computer
- One of the two main components in infovis
  - Representation
  - Interaction
- Interaction is what distinguishes infovis from static visual representations on paper

Interaction

- How do you define “interactive”?
Response Time

- 0.1 sec
  - animation, visual continuity, sliders
- 1 sec
  - system response, conversation break
- 10 sec
  - cognitive response

Interaction Types

- Dix and Ellis (AVI '98) propose
  - Highlighting and focus
  - Accessing extra info – drill down and hyperlinks
  - Overview and context – zooming and fisheyes
  - Same representation, changing parameters
  - Linking representations – temporal fusion
Interaction Types

- Keim’s taxonomy (TVCG '02) includes
  - Projection
  - Filtering
  - Zooming
  - Distortion
  - Linking and brushing

Selection

- User isolates a subset of the display components that will then be subjected to some other operation, such as highlighting, deleting, masking, drilling down, or moving to the center of focus.
- Selection can also be classified as to whether the user clicks on entities, paints over a selection of entities (e.g., holding the mouse button down while moving over the entities of interest), or otherwise isolating the entities via techniques such as bounding boxes and lassoes.
Pop-up tooltips

- Hovering mouse cursor brings up details of item
- Example: Microsoft office

Excentric Labeling

“Excentric Labeling: Dynamic Neighborhood Labeling for Data Visualization”
Jean-Daniel Fekete, Catherine Plaisant
SIGCHI conference on Human Factors in Computing systems in 1999
In this paper….

- Difficulties of labeling in Information abundant InfoViz applications.
- Informal Taxonomy of Labeling Techniques
- Excentric Labeling method introduced

Labeling Challenges…

- Readable
- Non-ambiguously related to its graphical object
- Does not hide any pertinent information.
## Taxonomy of labeling...

<table>
<thead>
<tr>
<th>Type</th>
<th>Technique</th>
<th>Comments/Problems</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>STATIC</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>No label</td>
<td>No labels!</td>
</tr>
<tr>
<td></td>
<td>Label-only-when-you-can (i.e. after filtering objects)</td>
<td>Need effective filters. Labels are rarely visible.</td>
</tr>
<tr>
<td></td>
<td>Rapid Label-All</td>
<td>High risk of overlaps or ambiguous linking to objects</td>
</tr>
<tr>
<td></td>
<td>Optimized Label-All</td>
<td>Often slow - may not be possible</td>
</tr>
<tr>
<td></td>
<td>Optimized Label-All with aggregation and sampling</td>
<td>Effective but application dependant - may not be possible</td>
</tr>
</tbody>
</table>

## Taxonomy of labeling...

- **Dynamic**

  | One at a time | Cursor sensitive balloon label | Requires series of precise selection to explore space (slow), cannot reach overlapped objects. |
  |               | Cursor Sensitive label in side-window | Same as above. Constant eye movement can be a problem, but avoids occlusion of other objects. |
  |               | Temporal brushing (Cleveland) | More labels visible at a time, but overlapping problem. |
### Dynamic

<table>
<thead>
<tr>
<th>Global display change</th>
<th>Zoom until labels appear</th>
<th>May require extensive navigation to see many labels (can be effectively combined with semantic zooming, e.g., Pad++)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Filter until labels appear</td>
<td>May require several filtering to see labels (can be effectively combined with Zooming, e.g., starfields)</td>
</tr>
</tbody>
</table>

### Dynamic

<table>
<thead>
<tr>
<th>Focus + context</th>
<th>Overview and detail view without deformation</th>
<th>Effective when objects are separated enough in the detail view to allow labels to fit (not guaranteed.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Overview and detail with deformation/ transformation (i.e. fisheye or magic lenses)</td>
<td>Deformation might allow enough room for labels to fit. (not guaranteed). May require tool or mode to be selected.</td>
</tr>
<tr>
<td></td>
<td>Global deformation of space (e.g., Hyperbolic Browser)</td>
<td>Requires intensive navigation and dexterity to rapidly deform the space and reveal all labels (e.g., by fanning the space).</td>
</tr>
</tbody>
</table>
Taxonomy of labeling...

Dynamic

- **Sampling**: Dynamic sampling (Chalmers et al.)
- New: Excentric labeling

<table>
<thead>
<tr>
<th>Few labels are visible.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fast, no tool or special skill needed. Spread overlapping labels, and align them for ease of reading.</td>
</tr>
</tbody>
</table>

Algorithm

1. Extract each label and position for interesting graphic objects in the focus region.
2. Compute an initial position.
3. Compute an ordering.
4. Assign the labels to either a right or left set.
5. Stack the left and right labels according to their order.
6. Minimize the vertical distance of each set from the computed initial position.
7. Add lines to connect the labels to their related graphic object.
Excentric Labeling

- Demo

http://www.cs.umd.edu/hcil/excentric/#prototypes

Excentric Labeling

- Comparison of excentric with virtual instantaneous zoom.
  - a 60% speed advantage for the excentric
  - Easily learnable after a little practice.
  - No of operations in zoom was much more
Details-on-Demand

- Term used in infovis when providing viewer with more information/details about data case or cases
- May just be more info about a case
- May be moving from aggregation view to individual view
  - May not be showing all the data due to scale problem
  - May be showing some abstraction of groups of elements
  - Expand set of data to show more details, perhaps individual cases

Zooming/Panning

- **Zooming in** - the interaction that changes the current display from a view of a lower level of detail to a view of a higher level of detail.
- **Zooming out** - the interaction that changes the current display from a view of a higher level of detail to a view of a lower level of detail.
- **Panning** - the interaction that changes the current display from a subregion of a view to an adjacent sub-region of the same view. There can be overlaps between the two regions.
Zooming in Screen-Space (Pixels)

- Example: Zooming in XmdvTool
- Demo

Zooming in Data Space

Interactive map from www.mapquest.com
Zooming in Topology Space

- Semantic zooming in Space-Optimized Tree

Panning and Zooming

- Panning in high levels of detail can be time consuming
  - Solution: zoom out, pan, and zoom in
  - Drawbacks: jitter in the process
- Improvement: Smooth and Efficient Zooming and Panning (van Wijk and Nuij, Infovis 03)
Panning and Zooming

- "Speed-Dependent Automatic Zooming for Browsing Large Documents" Igarashi & Hinckley, Proc. UIST'00, pp. 139-148.
  - Keep constant perceptual scrolling speed
  - Scale X Speed = Constant

Video!

Zooming and Panning

- **SpaceTree: Supporting Exploration in Large Node Link Tree, Design Evolution and Empirical Evaluation** Grosjean, Plaisant and Bederson, InfoVis 2002
  - A zooming environment that dynamically lays out branches of a tree to best fit and available screen space
  - Video
Distortion

- Distortion - an operation that increase the screen space allocated to some objects in the display while decreasing the screen space allocated to other objects.

Magnifier Lens

Figure from [Robertson & Mackinlay UIST 93]
FishEye Lens [Fur86]

Perspective Wall [MRC91]
Document Lens
[Robertson & Mackinlay UIST 93]

Table Lens [RC95]
Flip Zooming [Holmquist SIGCHI 97]

Flip Zooming
Hierarchical Image Browser
[Holmquist and Björk SIGGRAPH 98]

Complex Logarithmic Views for Small Details in Large Contexts. [J. Böttger et al. 06]

- Idea: use the complex logarithm and root functions to show very small details even in very large contexts (video)

Fig. 4. Transition from the identical mapping (left) to the logarithmic mapping (right) using scaled and shifted complex root functions.

Fig. 10. Stencil transfer (left) and complex logarithmic view with complex layout (right). The features of the different neuron layers are transformed to enhance visual contrast.
EdgeLens [Wong at. el. Infovis 03]

- Video (InfoVis 03)

MoireGraph
[Jankun-Kelly and Ma Infovis 03]

- Video (Infovis 03)
Datelens

- Video

InterRing

InterRing (infovis02)
Rearrange View

- Keep same fundamental representation and what data is being shown, but rearrange elements
  - Alter positioning
  - Sort

Rearrange
Sorting

- Can sort data with respect to a particular attribute in Table Lens

Changing Representation

- May interactively change entire data representation
  - Looking for new perspective
  - Limited real estate may force change
Changing Representation

Coordinated Views

- Reveal different aspect of the data
- Help navigation
Example – Visible Human Explorer

Example – Hierarchical Parallel Coordinates
Example – Lighthouse System

Example – XmdvTool
Example – Extended Parallel Coordinates

- Hauser et. al. Infovis 2002

Highlighting Connections

- Viewer may wish to examine different attributes of a data case simultaneously
- Alternatively, viewer may wish to view data case under different perspectives or representations
- But need to keep straight where the data case is
**Brushing**

- Applies when you have multiple views of the same data
- Selecting or highlighting a case in one view generates highlighting the case in the other views
- Very common technique in InfoVis

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**N-D Brushing**

[Diagram showing N-D Brushing with various axes and data points]
Structure-Based Brushing

- Demo

Filtering/Limiting

- Changing the set of data cases being presented
  - Focusing
  - Narrowing/widening
Video

- Filter for Boolean variables

Dynamic Query

- DB Queries
  
  Select house-address
  From atl-realty-db
  Where price >= 200,000 and
  price <= 400,000 and
  bathrooms >= 3
Typical Query Response

- 124 hits found
  - 1. 748 Oak St. - a beautiful …
  - 2. 623 Pine Ave.
  - …
- 0 hits found

Problems

- Must learn language
  - Only shows exact matches
  - Don’t know magnitude of results
  - No helpful context is shown
  - Reformulating to a new query can be slow
- …
Dynamic Query

- Specifying a query brings immediate display of results
- Responsive interaction (< .1 sec) with data, concurrent presentation of solution
- “Fly through the data”, promote exploration, make it a much more “live” experience

Dynamic Query Constituents

- Visual representation of world of action including both the objects and actions
- Rapid, incremental and reversible actions
- Selection by pointing (not typing)
- Immediate and continuous display of results
Idea at heart of Dynamic Query

- There often simply isn’t one perfect response to a query
- Want to understand a set of tradeoffs and choose some “best” compromise
- You may learn more about your problem as you explore

Alphaslider
Rangeslider

- 0
- Real data range
- 100
- Low selection thumb
- High selection thumb

Videos

- 1. Ben’s dynamic query talk
- 2. Filmfinder
- 2. Ben’s spotfire talk
DQ Strengths

- Work is faster
- Promote reversing, undo, exploration
- Very natural interaction
- Shows the data

Data Visualization Sliders

- Low selection thumb
- Data distribution
- High selection thumb
Brushing Histograms


Design Iterations

- 1st Stage: Plain DQ sliders
- 2nd stage: Add histograms on slider to clarify skewed distributions, but caused more confusion
- 3rd stage: Changed thumbs from arrows to bars, added mouse cursor
- Future: change to brushing, redesign histograms, continuous line, pixel-level granularity
Brushing Histograms

- Special case of brushing
- Data values represented in histograms that can be clicked on and selected (controls region)
- When items selected there, the corresponding item(s) are highlighted in main view windows
DQ vs. BH

- Empirical Study
  - Use DataMaps, a geographic (US states) data visualization tool
  - Have participants do different tasks with both methods
  - How many states have pop between x and y in 1970?
  - Given 3 states, which has the lowest median income?
  - What’s the relationship between education and income?
  - List states with pops. 0→x and y→z.
  - What kind of a state is Florida?

Findings

- Brushing histograms better and more highly rated for more complex discovery tasks
  - Attribute correlation, compare, and trend evaluation
  - Functioned more as its own infovis tool
- Dynamic queries better for more simple range specification tasks
  - Single range, multiple ranges, multiple criteria
  - Functioned more as auxiliary control for other vizs
Reference

- John stasko’s infovis class slides