Interaction

Information Visualization
May 26, 2008
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Housekeeping

- I moved to another office:
  Building E1 3, Room 429
“Little Brother”

- Two main components in an infovis
  - Representation
  - Interaction

- Representation gets all the attention
- Interaction is where the action is (no pun intended)

Research Focus

- Very challenging to come up with innovative, new visual representations
- But can do interesting work with how user interacts with the view or views
  - It’s what distinguishes infovis from static visual representations on paper

- Analysis is a process, often iterative with branches and side bars
Interaction

• Neglected aspect of infovis

• Call for “Science of interaction”

Definition

• What is “interaction”?
• How do you define “interactive”?
Definition

• A responsive system, one in which there is a back-and-forth dialog between the user and system

• Allows us to view multiple perspectives on the data or to examine particular data

Response Time

• .1 sec
  – animation, visual continuity, sliders

• 1 sec
  – system response, conversation break

• 10 sec
  – cognitive response
Example

Even simple interaction can be quite powerful

Stacked histogram

http://www.hiraeth.com/alan/topics/vis/hist.html

Example

www.digitalhistory.uh.edu/timeline/timeline.cfm
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
Examples

• Let’s take a look at what different systems provide
  – Focus on generalizing techniques

Selection

• Using pointer (typically) to select or identify an element
  – Often leads to drill-down for more details
**Pop-up tooltips**

- Hovering mouse cursor brings up details of item

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**Mouse Selection**

Clicking on an item selects it and attributes of the data point are shown

Selected item

Attributes
Labeling Visualizations

• Challenging problem
• Want
  – Be readable
  – Clearly linked to its graphical object
  – Do not hide any pertinent information
• Approaches
  – Static – Often all or nothing
  – Dynamic – How do you pick what & when?

Paper Recap

“Excentric Labeling: Dynamic Neighborhood Labeling for Data Visualization”

Jean-Daniel Fekete, Catherine Plaisant


Patrick Weinert
Motivation/Problem

• Need of a technique that:
  – offers readability
  – doesn't hide information
  – no ambiguous labels
Technique/Application

- Excentric Labeling:
  - extends the idea of tooltips
  - for a certain area around the cursor try to show all labels
Technique/Application

- Use of additional techniques to deal with:
  - alignment of labels
  - window boundaries
  - too many labels
  - long label names

Critique (Pros & Cons)

- Pros:
  - efficient
  - easy to use
  - good readability
  - detect overlapping data points

- Cons:
  - doesn’t show as much as possible
  - labels need a lot of free space
  - ambiguous labels without color
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

Direct Walk

• Linkages between cases
• Exploring one may lead to another
• Example:
  – Following hyperlinks on web pages
Rearrange View

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

Rearrange

In TableLens you can move columns (attributes) left and right
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
Example

Selecting different representation from options at bottom

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
Filtering/Limiting

- Fundamental interactive operation in infovis is changing the set of data cases being presented
  - Focusing
  - Narrowing/widening

Aggregation

- Interactively select many data cases on display and aggregate them together to be represented as one unit or cluster
Zooming/Panning

- Many infovis systems provide zooming and panning capabilities on display
  - Pure geometric zoom
  - Semantic zoom

- Will be a focus of ours later this term...
  - Day devoted to topic

Dynamic Query

- Probably best-known and one of most useful infovis techniques
- Let’s explore more details...
DB Queries

• Query language
  – Select house-address
    From atl-realty-db
    Where price >= 200,000 and
      price <= 400,000 and
      bathrooms >= 3 and
      garage == 2 and
      bedrooms >= 4

• Pluses?

• Minuses?
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
  - Timesharing vs. batch

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

Shneiderman
IEEE Software ‘94

Ahlberg & Shneiderman
CHI ‘94
Imperfection

• 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

Software Demo

• HomeFinder - Univ. of Maryland
New HouseFinder site

http://www.housingmaps.com

FilmFinder
Query Controls

- Variable types
  - Binary nominal - Buttons
  - Nominal with low cardinality - Radio buttons
  - Ordinal, quantitative - sliders

Alphaslider

- Goldfinger
- Current selection
- Slider thumb
- Slider area
- Index
Rangeslider

Low selection thumb

Real data range

High selection thumb

Spotfire

Summer term 2008
Spotfire Features

- Starfield display
- Tight coupling
  - features to guide the user
  - rapid, incremental, reversible interactions
  - display invariants
  - continuous display
  - progressive refinement
  - details on demand

Nice Application

www.myrateplan.com/cellphones
Another Example

www.bluenile.com/diamond_search.asp?track=dss

Summer term 2008 58

DQ Strengths

• ?
DQ Strengths

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

DQ Weaknesses

- ?
DQ Weakness

• Operations are fundamentally conjunctive
• Can you formulate an arbitrary boolean expression?
  – !(A1 V A2) ^ A3 V (A4 V A5 ^ A6) V ...

• But do people really do this often?

DQ Weakness

• Controls are global in scope
  – They affect everything

• Controls must be fixed in advance
**DQ Weakness**

- Controls take space!
  - How much in Spotfire?

- Put data in controls...

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**Data Visualization Sliders**

- Low selection thumb
- Data distribution
- High selection thumb

From: Eick, UIST ’94
DQ Weakness

- As data set gets larger, real-time interaction becomes increasingly difficult
- Storage - Data structures
  - linear array
  - grid file
  - quad, k-d trees
  - bit vectors

Tanin et al
InfoVis ’97

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?

Li & North
InfoVis '03
Findings

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

DQ vs. BH

• Fundamental Differences:
  – BH highlights data of interest; DQ filters unwanted data
  – DQ does single range query; BH allows multiple ranges
  – DQ users interact with the query (low, hi); BH users interact directly with data
  – DQ visualizes query formulation (1 way); BH displays query results too (I/O)

Li & North, ‘03
**DQ Limitation**

- You only see what is currently meeting query criteria
  - Yes, you can rapidly move sliders, but this requires the interaction
- Can we show what’s “nearby”?

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**Paper Recap**

“The Attribute Explorer: information synthesis via exploration”

Robert Spence, Lisa Tweedie


Daniel Fischer
Motivation

Common assumptions of the conventional “information retrieval” approach:

- user is familiar with the relevant database
- user has a precisely formulated question
- answer is usually a satisfactory solution
- little need to formulate a revised question
- user is trained to access the database

Problems

- Without some insight it is almost impossible to formulate a useful question.
- User often gets no results or too much results – without any hint how to modify the query for a useful solution.
- Contextual data is hidden, so it is difficult for the user to built an internal model.

Solution: “Information Synthesis”
Technique/Application

- For each attribute there is a histogram showing the number of objects for the different values of that attribute.

Technique/Application

- The user can define upper/lower limits for every attribute. The number of matching objects is visualized by color-coding in all histograms, thereby revealing relations between attributes.
Technique/Application

- Additive color-coding allows to show not only the objects matching all limits but also those objects violating only few limits.

Critique (Pros & Cons)

- no data is hidden
- queries have immediate effect on all views
- partial matches are indicated
- user is guided to a useful solution
  - queries are of limited power
  - less intuitive than dynamic queries
  - histograms not applicable to all topics
**DQ Disadvantage**

- Operations are global in scope
- Can we do something to fix that...?

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**Paper Recap**

**Enhanced Dynamic Queries via Movable Filters**

Ken Fishkin  
Maureen C. Stone

Proc. of CHI '95, pp. 415-420

Haichao Guan
Motivation/Problem

- Trad. Database Query Systems
  - Powerful and expressive: lots of information
  - Construction of database queries from specialized language primitives
  - BUT: Problem with usage (browsing or exploring)

- A Solution:
  - Graphical Presentation of Data 🔄 InfoVis Systems
  - Technique for direct manipulation

Technique/Application

- Extending dynamic queries
  - encoding operands of the query as a Magic Lens filter

- One Magic Lens represents one query
  - screens on some attribute of the data
  - Slider, Buttons and other control mechanisms
  - Placed for example over a city map or country map

- Compound queries:
  - Overlapping several Magic Lenses
  - Combination of Operations
**Technique/Application**

- **Boolean Queries**
  - AND, OR, NOT
  - Lenses with composition mode: Lense = (Filter,Mode) e.g. L1=(F1,OR), L2=(F2,AND),...
  - Higher Level Boolean Queries: (A OR B) AND (C OR D)...
  - \( \Rightarrow \) realized by composition of lenses

![Figure 1a: High salaries AND low taxes.](image1.png)

![Figure 1b: High salaries OR low taxes. Both conjunctive (AND) and disjunctive (OR) queries are incorporated in our system.](image2.png)

**Technique/Application**

- **Extensions 1:**
  - Real-Valued Queries: more detailed information
  - Sorting Lens

![Figure 4b: Boolean query on Texas.](image3.png)

![Figure 5: A sorting lens sorts cities by crime rate in Florida.](image4.png)
Technique/Application

• Extensions 2:
  − Missing Data: not all data provided

Critique (Pros & Cons)

• Pros:
  − Expressive yet easy to understand
  − Easy to use
  − Full power of a boolean query language

• Cons:
  − Too many Lenses maybe too much
  − Can't see map below lenses
  − No Names, one can only guess for example the city names
Supporting Representation

- Interaction in many cases is vital to representation
  - Provides useful perspective
    Many, many examples:
    Parallel coords, InfoZoom, anything 3D
  - Necessary for clarifying representation
    Dust & Magnet

Dust & Magnet

Demo

Yi et al
*Information Visualization* ’05
Sources Used

- Spence, CMS books
- Shneiderman; Ahlberg et al; Tweedie et al articles
- Chiu & Wang F99 slides