Interaction

CS 4460/7450 - Information Visualization
Feb. 24, 2009
John Stasko

Interaction?

- What do you mean by “interaction”?
Background

• Interaction
  = “The communication between user and the system” [Dix et al., 1998]
  = “Direct manipulation and instantaneous change” [Becker et al., 1987]

  “HCI research is far from having solid (and falsifiable) theories of interaction”
  [Beaudouin-Lafon, 2004]

Clarifying...

Interaction
Being interactive, not static

Interaction
Communication, analytic discourse
“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

- How do you define “interactive”?

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

- Keim’s taxonomy (TVCG ’02) includes
  - Projection
  - Filtering
  - Zooming
  - Distortion
  - Linking and brushing
Toward a Deeper Understanding of the Role of Interaction in Information Visualization

J. Soo Yi, Yoon ah Kang, John T. Dasko, Member, IEEE, and Julia A. Jacko

Abstract—Even though interaction is an important part of information visualization (Infovis), it has garnered relatively little attention from the Infovis community. A few frameworks and taxonomies of Infovis interaction techniques exist, but they typically focus on visualizations and do not address the variety of benefits interaction provides. After conducting an extensive literature review, we identified 311 individual information visualization interaction techniques widely used in Infovis. These include: Mappings, 11 Mapping; 11 Navigation; 11 Focus; 11 Focus + Context; 11 Visual Analytics; 11 Filter, and 11 Compare. These categories were organized around a user-centric view where interaction is related to a system. The categories can act as a framework to help discover and evaluate interaction techniques and potentially lay the foundation toward a deeper understanding of the role of interaction.

Index Terms—Interaction visualization, interaction, interactive techniques, taxonomy, visual analytics

1 Introduction

Interaction visualization (Infovis) systems, as their name suggests, have two main components: representation and interaction. The representation component defines what information is displayed, how the information is perceived by the user, and how the interaction with the system is executed on the display. The interaction component involves the dialog between the two and the system as the user explores the data set to achieve insights. The interaction component is not the same as human-computer interaction (HCI). Although discussed in two separate components, they are interrelated. Interaction visualization (Infovis) systems have a shared interface: a representation and an interaction component. Interaction with a system may activate a change in representation. Therefore, the two components seem to compose the two fundamental aspects of Infovis systems, and it seems reasonable to consider what each contributes to the development of visualization systems and their evaluation.

2.1 Survey

Study Methodology

- **Survey**
  - 59 papers
    - Papers introducing new interaction systems
    - Well-known papers in subareas of Infovis
  - 51 systems
    - Commercial Infovis Systems (SeeIT, Spotfire, TableLens, InfoZoom, etc.)
- Collected 311 individual interaction techniques
- **Affinity Diagram Method**
Focus Emerged

User intent

“What a user wants to achieve through a specific interaction technique”

Main Idea

• Don’t focus so much on particular interactive operations and how they work

• Interaction is ultimately being done by a person for a purpose
  – Seeking more information
  – Fundamental aspect of exploratory, analytic discourse
Results

7 categories
Select
Explore
Reconfigure
Encode
Abstract/Elaborate
Filter
Connect

1. Select

“Mark something as interesting”

- Mark items of interest to keep track
- Seems to often work as a preceding action to subsequent operations.

e.g.,
- Selecting a placemark in Google Map
- The Focus feature in TableLens
Pop-up tooltips

- Hovering mouse cursor brings up details of item

Mouse Selection

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

Selected item

Attributes
But...

What's wrong with this picture?

Problem

- Where are the labels?
  - Labeling is difficult to do when so many entities exist
  - Can add to ball of string problem
Objectives

- Each label for a data point should:
  - Be readable
  - Non-ambiguously relate to its graphical object
  - Not hide other pertinent information
- Completeness (labeling of all objects) is desired but not always possible

Two types of techniques

- Static
  - Road maps
  - Physical presentations
  - Used in cartography
- Dynamic
  - Interactive data points
Excentric Labeling

- Area of focus
- Line and box color match the color of the data point
- Description boxes containing the name of the data point

Fekete and Plaisant
CHI '99

Being Excentric

- “Invisible” – Does not appear until user hovers over data points
- Describes data points using the name field
- Visually connects labels with data points
- Can order labels to indicate graph position

Demos at http://www.cs.umd.edu/hcil/excentric
2. Explore

“Show me something different”

- Enable users to examine a different subset of data
- Overcome the limitation of display size

E.g.,
- Panning in Google Earth
- Direct Walking in Visual Thesaurus

Direct Walk

- Linkages between cases
- Exploring one may lead to another
- Example:
  - Following hyperlinks on web pages
Example

Visual Thesaurus

http://www.visualthesaurus.com

3. Reconfigure

“Show me a different arrangement”

- Provide different perspectives by changing the spatial arrangement of representation

  e.g.,
  - Sorting and rearranging columns in TableLens
  - Changing the attributes in a scatter plot
  - The baseline adjustment feature in Stacked Histogram
  - The “Spread Dust” feature in Dust & Magnet
Rearrange View

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

Example

Stacked Histogram
Rearrange

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

Sorting

Can sort data with respect to a particular attribute in Table Lens.
4. Encode

“Show me a different representation”

• Change visual appearances

e.g.,
• Changing color encoding
• Changing size
• Changing orientation
• Changing font
• Changing shape

Changing Representation

• May interactively change entire data representation
  – Looking for new perspective
  – Limited real estate may force change
5. Abstract/Elaborate

“Show me more or less detail”

- Adjust the level of abstraction (overview and details)

  e.g.,
  - Unfolding sub-categories in an interactive pie chart
  - Drill-down in Treemap
  - Details-on-demand in Sunburst
  - The tool-tip operation in SeeIT
  - Zooming (geometric zooming)
**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

---

**Examples**

- Google Earth
- SeeIT
- Table Lens
Example

Animated SunBurst

6. Filter

“Show me something conditionally”

- Change the set of data items being presented based on some specific conditions.

  e.g.,
  - Dynamic query
  - Attribute Explorer
  - Keystoke based filtering in NameVoyager
  - QuerySketch
Filtering/Limiting

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

Example

NameVoyager
Example

- Faceted metadata
  - Attributes of datasets are grouped into multiple orthogonal categories
  - Selecting a value from one filters on that value and updates the items in other categories
  - User explores data collection by series of selections
FacetMap

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 \(\geq 200,000\) and
  price \(\leq 400,000\) and
  bathrooms \(\geq 3\) and
  garage \(\equiv 2\) and
  bedrooms \(\geq 4\)

DB Queries

• 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
• ...

Spring 2009 CS 4460/7450
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

DQ Examples

- HomeFinder - Univ. of Maryland

![HomeFinder Screen Shot](Image)
Spotfire Features

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

www.myrateplan.com/cellphones

Spring 2009

Another


Spring 2009

Note quite DQ though
DQ Strengths

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

- ?

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...

Spring 2009 CS 4460/7450 66
Data Visualization Sliders

- Low selection thumb
- Data distribution
- High selection thumb

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

BH Example

DataMaps
Maryland & Va Tech
Demo
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 viszs
**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)

---

**Attribute Explorer**  
Spence & Tweedie  
Int w Computers '98

- **Attribute histogram**
- All objects on all attribute scales
- Interaction with attributes limits
- Brushing across views
- Color-encoded sensitivity

Spring 2009  
CS 4460/7450  
73
DQ Disadvantage

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

Magic Lenses

Figure 10a) High salaries AND low taxes.

Fishkin & Stone
CHI ’95
7. Connect

“Show me related items”

- Highlight associations and relationships
- Show hidden data items that are relevant to a specified item

e.g.,
- Highlighting directly connected nodes in Vizster
- Brushing in InfoScope

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
Example

Let’s take a step back and think about representation & interaction again.
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
Key Points

- Multiple views amplify importance of interaction

- Interaction facilitates a dialog between the user and the visualization system

Administrativa

- HW 4 due Thursday
- Questions?
Upcoming

- Overview and Detail (Focus + Context)
  - Reading:
    Baldonado paper