Interaction 1

CS 7450 - Information Visualization
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Interaction?

• What do you mean by “interaction”? 
Background

• Interaction (HCI)
  = “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

Today's focus

Interaction
  Communication, analytic discourse
Main Components

“The effectiveness of information visualization hinges on two things: its ability to clearly and accurately represent information and our ability to interact with it to figure out what the information means.”

S. Few
Now You See It, p. 55

“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”? 
One Way: 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
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

Another Taxonomy

• Operator
  – navigation, selection, manipulation, distortion, filtering

• Space of interaction
  – screen, data value, data structure, attribute, object, visualization structure

• Parameters of the interaction operator
  – focus, extents, transformation, blender

Ward, Grinstein, & Keim
2010, chapter 10
Few’s Principles

• Especially useful ways of interacting with data
  - Comparing
  - Sorting
  - Adding variables
  - Filtering
  - Highlighting
  - Aggregating
  - Re-expressing
  - Re-visualizing
  - Zooming and panning
  - Re-scaling
  - Accessing details on demand
  - Annotating
  - Bookmarking

Now You See It
Chapter 4

Details

• Sorting (for example)
  - Provide a selection of graphs that support the full spectrum of needed comparisons
  - Provide graphs that are designed for easy comparison of those values and relevant patterns without distraction
  - Provide the means to place a great deal of information that we wish to compare on the screen at the same time, thereby avoiding the need to scroll or move from screen to screen to see the information

Great design checks for your visualization systems
Challenging

• Interaction seems to be a difficult thing to pin down and characterize

• Let’s go back to the user trying to solve problems...
  – User-centered versus system-centered characterizations
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, solving a problem
  - 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.

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

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**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

Generalized Selection

- When you click on an item in a visualization, can we generalize the selection off the precise item?
  - Maybe you want to select items matching some attribute(s) of that item
Query Relaxation

As you dwell on your mouse pick, the selection criteria broaden and you can choose sets of items

Video

Heer, Agrawala, Willett
CHI ’08

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

http://www.visualthesaurus.com

Visual Thesaurus
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

Example

Selecting different representation from options at bottom
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

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

http://www.babynamewizard.com/namevoyager.html/

Filtering
Filtering

Click a name graph to view that name. Double click to read more about it.

Example
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

Smith et al
TVCG ‘06
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
DB Queries

- Pros?
  - Powerful, flexible

- Cons?

Typical Query Response

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

- 0 hits found
Further Cons

- 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

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

FilmFinder

C. Ahlberg
Maryland

Video
What Did We See?

- Interface
  - buttons
  - sliders (nominal --> ordinal)
  - alphasliders

Query Controls

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

Current selection
Slider thumb
Slider area
Index

Rangeslider

Low selection thumb
Real data range
High selection thumb
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

Another

Note quite DQ though

DQ Pros

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

• 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 Cons

- Controls are global in scope
  - They affect everything

- Controls must be fixed in advance

DQ Cons

- Controls take space!
  - How much in Spotfire?

- Put data in controls...
Data Visualization Sliders

- Low selection thumb
- Data distribution
- High selection thumb

Eick
UIST '94

DQ Cons

- 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?

**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 vizzes

Li & North
InfoVis '03
BH versus DQ

- BH
  - Highlights data of interest
  - Allows multiple ranges of selection
  - Users interact directly with data
  - Displays query results too (I/O)

- DQ
  - Filters out unwanted data
  - Does single range query
  - Users interact with the query (low, hi)
  - Visualizes query formulation (1 way)

Attribute Explorer

- Spence & Tweedie
  - Inter w Computers '98

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

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

Magic Lenses

Figure 1(a): High salaries AND low taxes.

Video

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
Interaction Characteristics

- Fluidity a key
  - Promotes “flow”
    - Balanced challenge
    - Concentration
    - Loss of self-consciousness
    - Transformation of time
    - Prompt feedback
    - Sense of control
    - Intrinsically rewarding
  - Supports direct manipulation
  - Minimizes the gulfs of action

Elmqvist et al
*Information Visualization ’11*
Fluidity Design Guidelines

- Use smooth animated transitions between states
- Provide immediate visual feedback on interaction
- Minimize indirection in the interface
- Integrate user interface components in the visual representation
- Reward interaction
- Ensure that interaction never ‘ends’
- Reinforce a clear conceptual model
- Avoid explicit mode changes

OK

- 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

HW 3 Discussion

- What was challenging?
- What are some good approaches?
  - See examples
Upcoming

• Storytelling
  – Reading:
    Segel & Heer ‘10

• Guest speakers