5. Interaction with Visualizations
Dynamic linking, brushing and filtering in Information Visualization displays

Lecture „Informationsvisualisierung”
Prof. Dr. Andreas Butz, WS 2012/13
Concept and slides: Thorsten Büring,
3rd, revised edition
Outline

• InfoVis & Interaction
• Direct Manipulation (DM)
• Common Interaction Techniques
  – Brushing
  – Zooming & Panning
  – Dynamic Queries
• Attribute Explorer
• Dynamic Queries and Movable Filters
InfoVis & Interaction

• Information Visualization research originally: focus on finding novel visual representations
• Increasing interest in interaction design, HCI models and evaluation as well as aesthetics in the InfoVis community
• HCI Interaction models help us to better understand the complex concepts of human-machine communication
• Norman’s execution-evaluation cycle (Norman 1988)
  – 1. Establishing the goal
  – 2. Forming the intention
  – 3. Specifying the action sequence
  – 4. Executing the interaction
  – 5. Perceiving the system state
  – 6. Interpreting the system state
  – 7. Evaluating the system state with respect to the goals and intentions
Simple Interaction Example

- Stacked histogram
  - how are the banana sales progressing???
  - http://www.hiraeth.com/alan/topics/vis/hist.html
Direct Manipulation (DM)

• Shneiderman 1982
• DM features
  – Visibility of all objects of interest
  – Incremental actions with rapid feedback on all actions
  – Reversibility of all actions, so that users are encouraged to explore without penalties
  – Syntactic correctness of all actions, so that every user action is a legal operation

• DM does not only make interaction easier for novice users but fundamentally extends visualization capabilities
Common Interaction Techniques

• Details-on-demand
  – Provides improved scalability by displaying information about data case(s) on demand to the user
  – View may move from aggregation of objects to the elements contained

• Direct Walk
  – Linkage between cases
  – Exploring one case may lead to another (e.g. hyperlinks on news page)

• Manipulate View
  – Rearrange view (e.g. move view position, sorting items in a table)
  – Change representation (e.g. from histogram to scatterplot)

• Linking
  – Connection between multiple views of the same data space
  – Updating one view means updating all
Brushing

- Becker & Cleveland 1987
- A collection of dynamic methods for viewing multidimensional data
- Brush is an interactive interface tool to select / mark subsets of data in a single view, e.g. by sweeping a virtual brush across items of interest
- Given linked views (e.g. scatterplot matrix) the brushing can support the identification of correlations across multiple dimensions (brushing & linking)
- Usually used to visually filter data (via highlighting)
- Additional manipulation / operations may be performed on the subsets (masking, magnification, labeling etc.)
- Different types of brushes (Hauser et al. 2002))
  - Simple brush via sweeping
  - Composite brush: composed multiple single-axis brushes by the use of logical operators
  - Angular brush
  - Smooth brush

Composite scatterplot brushes - Hauser et al. 2002
Brushing Example

- Brushing one dimension in parallel coordinates to highlight car data objects with 4 cylinders

Hauser et al. 2002
Brushing a parallel coordinate plot

Angular Brush

- Angular brush: brushing by specifying a slope range – highlight correlation and outliers between two dimensions

Hauser et al. 2002
Smooth Brush

- Non-binary brushing
- Degree-of-interest defined by distance to brushed range
- Decreasing degree is mapped to decreasing drawing intensity
Another Brushing Example

• Example for composite (AND) brush in Parallel Coordinate Plot – find the cities with high wages, small prices and many paid holiday days

Zooming & Panning

- Moving from overview to detail: another way to filter data / focus on a subset of data
- Scale and translation of the viewport
- Geometrical versus semantic zooming
- Topic of a lecture to come (lecture 10: presentation I)
Dynamic Queries

• Shneiderman 1994
• Explore and search databases
• SQL example: SELECT customer_id, customer_name, COUNT(order_id) as total FROM customers INNER JOIN orders ON customers.customer_id = orders.customer_id GROUP BY customer_id, customer_name HAVING COUNT(order_id) > 5 ORDER BY COUNT(order_id) DESC
• Problems
  – Takes time to learn
  – Takes time to formulate and reformulate
  – User must know what she is looking for – only exact matches
  – Lots of ways to fail
  – SQL error messages helpful?
  – Zero hits – what component is to be changed?
Dynamic Queries

• Based on Direct Manipulation (DM)

• DM principles with regard to Dynamic Queries
  – Visual presentation of the query’s components
  – Visual presentation of results
  – Rapid, incremental, and reversible control of the query
  – Selection by pointing, not typing
  – Immediate, continuous feedback

• Implementation approach
  – Graphical query formulation: Users formulate queries by adjusting sliders, pressing buttons, bounding box selection…
  – Search results displayed are continuously updated (< 100 ms)
Examples

• Visual representations of data to query?
• Some examples: geographic data, starfields, tables etc.

Shneiderman 1994
HomeFinder

• One of the first DQ interfaces
• Williamson & Shneiderman 1983(!)
FilmFinder

- Ahlberg & Shneiderman 1994
Dynamic Query Controls

• Check boxes and buttons (Nominal with low cardinality)
• Sliders and range slider (ordinal and quantitative data)
• Alphaslider (ordinal data) (Ahlberg & Shneiderman 1994)
  – Small-sized widget to search sorted lists
  – Online-text output
  – Two-tiled slider thumb for dragging operations with different granularities
  – Letter index visualizing the distribution of initial letters – jump to a position in the slider
  – Locating an item out of 10,000 items ~ 28s for novice users
  – Pros and cons to text entry?

• Redesigned Alphaslider for PDAs / MP3 player - movie
• Extend data sliders with data visualization (Eick 1994)
Dynamic Queries Online

- Online examples: [http://immo.search.ch](http://immo.search.ch) and diamond search ([http://www.bluenile.com](http://www.bluenile.com))
DQ in current search interfaces

- DQ have become widespread with fast search algorithms and increased computing capacity
  - search happens while typing in search terms in google search
  - new routes are calculated while point is dragged in google maps
Making Money with Dynamic Queries

- Starfield displays and Dynamic Queries provided the basis for SpotFire
- Christopher Ahlberg
  - 1991: Visiting student from Sweden at the HCIL University of Maryland
  - 1996: Founder of SpotFire
  - 2007: SpotFire was sold for 195 Mio. $
- Well done!
Summary Dynamic Queries

• Users can rapidly, safely playfully explore a data space – no false input possible
  – Users can rapidly generate new queries based on incidental learning
  – Visual representation of data supports data exploration
  – Analysis by continuously developing and testing hypotheses (detect clusters, outliers, trends in multivariate data)
  – Provides straightforward undo and reversing of actions

Potential problems with DQ as implemented in the FilmFinder?
Limit of query complexity – filters are always conjunctive
Performance is limited for very large data sets and client / server applications
Controls require valuable display space
Information is pruned
Only single range queries and single selection in the alphaslider
Case Study: The Attribute Explorer

- Tweedie et al. 1994
- Example for DQ, brushing & linking and fuzzy search
- Linked histograms to search and explore multivariate data
- Filtering data via range sliders
- Color-coding to highlight and discriminate data cases across views
- Sensitivity information: visualizes how well data cases meet the filter requirements
- Particularly useful for zero-hits situations

Spence 2004
• The Attribute Explorer
Dynamic Queries and Movable Filters

• Fishkin and Stone 1995
• Dynamic Queries (DQ)
  – Disjunctive queries can only be performed by sequential querying
  – Effect of DQ is global – no way to limit filtering to only a portion of the data
  – Number of possible queries is fixed in advance
• Combine approach with magic lens filters
  – Arbitrarily-shaped region with an operator that manipulates the view of underlying objects
  – Filters are spatially bounded – global context is maintained
  – Filters that overlap compose their effects in the overlap region

Stone et al. 1994
Magnify Circle

Mac Lenses
Idea & Implementation

• Each lens acts as a filter that screens on some attribute of the data

• Lens components
  – Filtering function (what to filter)
  – Composition mode (how to combine the filter result with lenses underneath, i.e. AND, OR, NOT)

• Composition modes are implemented as buttons on the lens

• Grouping: Replace a stack of lenses by a single compound lens, which also has a composition mode

• Compound lenses may contain other compound lenses

• Boolean queries and grouping allow queries of arbitrary complexity

• Multiple concurrent queries on different portions of the data space
Parallel sets: recent de.js implementation
Additional Sources

- Lecture material CS 7450 John Stasko, 2006