Too Much Data?

How can we deal with data overload

- see the forest for the trees (or the other way around)
Too Much Data?

Internet routes (1/15/2005)
(NY Museum of Modern Art)
The Key to Overcome the Data Deluge: Interaction

Allow users to control what is currently shown:
  • level of detail
  • extent of the data (spatial, values)
  • aspects of the data (attributes)

But do not leave the user lost in the forest
  • provide navigation hints

Two powerful paradigms:
  • overview, and detail on demand (forest and trees)
  • focus and context (trees and forest)

Interaction needs to be interactive (as in responsive)
  • user needs to get quick visual feedback on actions
Interaction: Key to Visual Analytics

Puts the human in the loop
  • appeals to human’s expertise and intuition

Requires a suitable human-computer interface
  • recall the lectures on color and perception

Interaction can help with:
  • making sense of it all
  • putting things in proper context
  • data overload (scalability)
  • telling stories with data (explain findings to others)

Evaluate effectiveness
  • do human users actually benefit?
  • user studies!
A Taxonomy of Fundamental Interaction Types

Stephen Few (chapter 4):

- compare
- sort
- add variables
- re-scale
- re-express
- filter
- highlight
- annotate
- bookmark
- aggregate
- re-visualize
- zoom and pan
- details on demand
Assume you have been offered a car to buy

• assume you are mostly interested in horsepower, weight, acceleration
• the car you have been offered has 60 hp, 1834 kg, 8 s

![Horsepower Chart]
Compare

See the car with other available cars

Horsepower

hard to see how it really ranks
See the car in the context of other available cars

it is a low-horsepower car
Is horsepower correlated to weight?

- are there trade-offs?

hard to see what is going on
Scale horsepower into the same range than weight
• could also normalize each to (0.0, 1.0)

There seems to be a positive correlation
• cars with higher horsepower are also heavier
Another Variable

How does it relate to acceleration?

The chart shows that non-intuitive to the viewer that acceleration is less for high horsepower cars.
Acceleration should really be $1/\text{acceleration}$

- should be measured in $1/\text{sec}$ (and not sec)

- now higher horsepower cars also seem to have higher acceleration (but the influence is quite minor) $\Rightarrow$ is there a higher-D relationship?
Example: Graph of concepts

- related concepts group closer

from: http://www.mkbergman.com/date/2008/02/
Filtering

Example: Graph of concepts
  • only keep top 750 connected nodes
Filtering

Example: Graph of concepts
- only keep top 350 connected nodes
Zooming

Example: Graph of concepts
• only keep Saab neighborhood
Example: Graph of concepts

- only keep Saab neighborhood, zoom in more
As discussed, good ways to aggregate all data into a single display are:

- biplots (project all data into a PCA vector basis)
- multidimensional Scaling (MDS)
- parallel coordinates
The Visual Information-Seeking Mantra

• devised 1996 by Ben Shneiderman (U Maryland, College Park)
• summarizes many visual design guidelines
• in some ways inspired by human vision/behavior
• provides an excellent framework for designing Information visualization applications.

Overview, zoom and filter, then details-on-demand
Information space overview plus some detail

- maintains (some) context with the detail currently focused on

Leica Microsystems

WikiViz
Overview and detail

• disjoint views, maybe connected by a fan
• but: they simultaneously shows both overview and details
• require the viewer to consciously shift his/her focus of attention
Focus + Context

Overview and detail
- disjoint views, maybe connected by a fan
- but: they simultaneously shows both overview and details
- require the viewer to consciously shift his/her focus of attention

Focus + context
- one single view which shows information in direct context
- maintains continuity across the display
- do not require viewer to shift back and forth
- a good F+C paradigm is the *lens*
- but: there will be distortion
Fisheye Lenses

Fisheye lenses
- physically correct and therefore familiar
- keep target item in focus
- less relevant peripheral items are dropped or reduces in size
- distortion
Bifocal Lens

Complete Mapped Information Space

Bifocal Display Seen by the User

Principle of the Bifocal Display

fold

project
Bifocal Lens

London subway map
Avoid aliasing in transition regions by low-pass filtering
Generalized Lenses

Computers can go beyond (stretch) the laws of physics

- example: multi-perspective lens rendering, gaze-directed, ...
Generalized Lenses

Wang et al., 2005
Hyperbolic Tree fisheye lens

- Xerox PARC/Inxight
- selectively and smoothly reduce complexity as user focus changes
Lenses in Information Visualization

Table Lens (Rao and Card, 1994)

- uses a DOI (degree of interest) lens
- fuses symbolic and graphical detail driven by the DOI lens
Lenses in Information Visualization

Perspective Wall

- Xerox PARC/Inxight
- details on the center panel are at least three times larger than the details on a flat wall that fits the field of view
Zoom and Pan

Panning
- smooth movement of a viewing frame over a 2D image of greater size

Zooming
- increasing magnification of a decreasing fraction (or vice-versa) of a 2D image under the constraint of a viewing frame of constant size

Transfer of the focus of attention:
- zoom out → pan → zoom in
Efficient transfer of the focus of attention:

- zoom out → pan → zoom in

Furnas, Bederson, 1995
Intelligent Zooming

Depending on scrolling speed, zoom more or less

- allows efficient navigation of large documents
- employs semantic zooming

Igarashi, Hinckley, 2000
Semantic Zoom

Standard zoom:
  shows a down/up scaled version of the object/image

Semantic zoom:
  • shows a different representation determined by the space available
Semantic Zooms: Maps
Could show different levels/aspects of information

- on a map, show either parking lots, bars, or restaurants
- zoom in by price range (cheap first, then more expensive…)
- zoom in by preference (favorite food first, then less favorite…)
- may combine these criteria into a preference function
Semantic Zooms: Information Visualization

Could show different levels/aspects of information

- on a map, show either parking lots, bars, or restaurants
- zoom in by price range (cheap first, then more expensive…)
- zoom in by preference (favorite food first, then less favorite…)
- may combine these criteria into a preference function

Zoom levels may require access rights

- members only
- big wallets only
- classified information

Information access rights:

- Human being
- Male
- Police man
- British policeman
- Inspector Blanding
Interactive technique

- Highlighting
- Brushing and Linking

At least two things must be linked together to allow for brushing

- select a subset of points
- see the role played by this subset of points in one or more other views

Example systems

- Graham Will’s EDV system
- Ahlberg & Sheiderman’s IVEE (Spotfire)
Linking Types of Assist Behavior to Position Played
Baseball Data: Scatterplots and Histograms and Bars

- how long in majors
- select high salaries
- avg assists vs avg putouts (fielding ability)
- avg career HRs vs avg career hits (batting ability)
- distribution of positions played
What was Learned from Interaction w/ the Baseball Data?

- Seems impossible to earn a high salary in the first three years
- High salaried players have a bimodal distribution (peaking around 7 & 13 yrs)
- Hits/Year a better indicator of salary than HR/Year
- High paid outlier with low HR and medium hits/year. Reason: person is player-coach
- There seem to be two differentiated groups in the put-outs/assists category (but not correlated with salary) Why?
Brushing: Highlighting

Use mouse interaction to highlight points and lines in

- parallel coordinates
- scatterplots
Based on Pearson’s correlation for all attribute pairs

- vertices: attributes
- edges: correlation between attributes
Correlation Graph

Use Mass-Spring Model for layout

Edge is weighted by the correlation

- negative, positive, or absolute

The correlation itself is encoded by color

- green: correlation = 1.0
- red: correlation = -1.0
- linear interpolation computes the colors in between.

-1.0 0.0 +1.0
Compute Optimal Path
Re-Order Parallel Coordinate Display
Responsiveness in Javascript/D3.js

Remember? - Interaction needs to be interactive
  • User needs to get quick visual feedback on actions

When does performance decrease in JavaScript?
Responsiveness in Javascript/D3.js

Remember? - Interaction needs to be interactive
  • User needs to get quick visual feedback on actions

When does performance decrease in JavaScript?
  • Mainly when the size of the dataset increases
Remember? - Interaction needs to be interactive
  • User needs to get quick visual feedback on actions

When does performance decrease in JavaScript?
  • Mainly when the size of the dataset increases

Two areas where performance drops:
  • Rendering (Increase in DOM nodes)
  • Filtering (More data items to compare)
Rendering issues have been addressed by using a Canvas instead of SVG

- One html element instead of multiple elements

How does it work?

- We draw/project a view of the data on to a canvas (Occluded points are not drawn).

Issues with using canvas:

- No sub-elements ⇒ interaction becomes non-trivial
- To support advanced interaction we need to maintain data structure in the memory.
Crossfilter.js: Solution to Filtering Issues

Filtering large datasets in the JSON format can be done quickly with Crossfilter.js

• Uses sorted indexes to improve performance of live histograms and top-K lists.

Crossfilter.js functionality:

• Filtering of course.
• Histogram computation.
• Sorting.

Example: http://selfiecity.net/selfiexploratory/

Library & Tutorial: http://square.github.io/crossfilter/
Multiple Linked Views (Dashboard)

Overview

Details/Zoom

Biplot/MDS

Parallel Coordinates

Histogram/Timeline

Individual Dimension
Brushing in D3.js

Support by d3-brush

Rectangular brush
- scatterplot matrix brushing
- scatterplot brushing
- brush and zoom

Polygonal brush
- polybrush
- github