Information Visualization

Pictures worth 1000 words...
Information Visualization overview

- Definition
- Principles
- Examples
- Techniques
Data, Data Everywhere

- Our world is bustling in data
- Computers, internet and web have given people more access to it (but it’s been here all along)

- How do we make sense of it?
- How do we harness this data in decision-making processes?
Consider Elections: Red or Blue?
Consider Elections: Red or Blue?

- OH-12 refers to the Aug. 7 special election.
- All "Safe" seats belong to the party that currently holds them except for PA-05, which is rated Safe Democratic.
Consider Elections: Red or Blue?
Three Approaches

- **Software Agents**
  - Computational agent that carries out user’s request

- **Data Mining**
  - Software that analyzes database and extracts “interesting” features

- **Information Visualization**
  - Visual tools to help users better examine the data themselves
Atlanta Flight Traffic

Hartsfield International averages more than 100 takeoffs and landings per hour. Wind direction determines the direction the planes fly. These diagrams show jet flights (propeller planes are not included) for two days in late 1999.

Takeoffs and landings to the east, against the wind

Wind direction

Douglasville
Decatur
Lithonia
Fairburn
Airport
Stockbridge
Peachtree City

AJC

Fall 2018
Underground Overlaid on London

100% Veridical Display is not always the goal...
(The real Thames is in dark blue)
Napoleonic’s March

From E. Tufte *The Visual Display of Quantitative Information*

Minard graphic  size of army  direction  latitude  longitude  temperature  date
What is “Information”?

- Items, entities, things which do not have a direct physical correspondence
- Notion of abstractness of the entities is important too
Information Visualization

What is “visualization”?

- The use of computer-supported, interactive visual representations of data to amplify cognition.
  - From [Card, Mackinlay Shneiderman ‘98]
Information Visualization

Essence:

- Taking items without a physical correspondence and mapping them to a 2-D or 3-D physical space.
- Giving information a visual representation that is useful for analysis and decision-making
Main Idea

“"The purpose of visualization is insight, not pictures”"

- Visuals help us think
  - External cognition
  - Provide a frame of reference, a temporary storage area
Domains for Info Vis

- Text
- Statistics
- Financial/business data
- Internet information
- Software
- ...

Fall 2018

PSYCH / CS 6755

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Components of Study

- Data analysis
  - Data items with attributes or variables
  - Generate data tables
- Visual structures
  - Spatial substrate, marks, graphical properties of marks
- UI and interaction
- Analytic tasks to be performed
Tasks in Info Vis 1

➢ Search
  ❖ Finding a specific piece of information
    • How many games did the Braves win in 1995?
    • What novels did Ian Fleming author?

➢ Browse
  ❖ Look over or inspect something in a more casual manner, seek interesting information
    • Learn about crystallography
    • What has Jane been up to lately?
Tasks in Info Vis 2

- Analysis
  - Comparison-Difference
  - Outliers, Extremes
  - Patterns
- Assimilate
- Categorize
- Locate
Tasks in Info Vis 3

- Identify
- Rank
- Associate
- Reveal
- Monitor
- Maintain awareness
- …
### Example

**NYC weather**

- **Annual Temperature**
  - Normal:
    - January: 30°F
    - February: 32°F
    - March: 50°F
    - April: 60°F
    - May: 70°F
    - June: 75°F
    - July: 102°F
    - August: 90°F
    - September: 75°F
    - October: 60°F
    - November: 50°F
    - December: 32°F

- **Precipitation in Inches**
  - Total Precipitation for 1980: 44.54 inches
  - Normal Precipitation: 40.19 inches

- **Relative Humidity as of Noon**


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**Tufte, Vol. 1**

**2220 numbers**
Film Finder

Example

Video

Witches of Eastwick, The
Director: Miller, George
Year: 1987
Country: USA
Language: English
Actors: Nicholson, Jack, Jenkins, Richard, Joakum, Keith, Struyker, Carel
Actresses: Cher, Sarandon, Susan, Pfeiffer, Michelle, Cartwright, Veronica

Title: ALL
Actor: ALL
Actress: Pfeiffer, Michelle
Director: Miller, George
Year: 1987
Country: USA
Language: English
Actors: Nicholson, Jack, Jenkins, Richard, Joakum, Keith, Struyker, Carel
Actresses: Cher, Sarandon, Susan, Pfeiffer, Michelle, Cartwright, Veronica

Films Shown: 210
Ratings: G, PG, PG-13, R
Length: 231 minutes

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Univ. of Maryland
InfoVis Techniques

- **Aggregation**
  - Accumulate individual elements into a larger unit to be presented as some whole

- **Overview & Detail**
  - Provide both global overview and detail zooming capabilities

- **Focus + Context**
  - Show details of one or more regions in a more global context (eg, fisheye)
InfoVis Techniques

- **Drill-down**
  - Select individual item or smaller set of items from a display for a more detailed view/analysis

- **Brushing**
  - Select or designate/specify value, then see pertinent items elsewhere on the display
Overview first, zoom and filter, then details on demand

-- Ben Shneiderman
Issues

➢ Graphic design

➢ Extremely important in information visualization

➢ Should reveal data and relationships, not obscure them

➢ Tufte books provide many guidelines
Issues

Scalability

- Presentation of information becomes really interesting as the size of the data grows
- Run out of pixels at some point
- Requires aggregation, navigation, ...
Interaction

- Computer provides interactive capability that we do not have in printed page
- Often, must navigate and examine different views of data to gain insight
More Examples

Demo
More Examples

Microsoft Research  Data Mountain
Variety of techniques

- Traditional tree views, alternatives, space-filling views
Hierarchies often represented as trees
Root at top, leaves at bottom
Sample Representation
Another Representation
Another Representation

root
Another Representation
Another Representation
Potential Problems

- Width of fan-out uses real estate
  - Run out of room quickly
Another Idea

CHEOPS

Beaudoin, Parent & Vroomen
Another Idea

ConeTree

Card, Mackinlay & Robertson
Another Idea

- Use hyperbolic geometry
- Hyperbolic tree

- Here: Site Lens from www.inxight.com

- Demo
Space-Filling Representation

Each item occupies an area

Children are “contained” under parent
Treemap

- Space-filling representation developed by Shneiderman and Johnson
- Children are drawn inside their parent
- Alternate horizontal and vertical slicing at each successive level
Treemap

File and directory visualizer

white-directories color-files

level 1 dirs
Treemap

Click on a region once to identify, twice to refocus.
Nested vs. Non-nested Treemaps

Nested Tree-Map

Non-nested Tree-Map
Treemap Affordances

- Good representation of two attributes: color and area
- Not as good at representing structure
  - What happens if it’s a perfectly balanced tree of items all the same size?
  - Also can get long-thin aspect ratios
Treemap Variation

SmartMoney Map of the Market (old)
- Illustrates stock movements
- “Compromises” treemap algorithm to avoid bad aspect ratios
Treemap Variation

- Use 3D shading cues to help convey structure

SequoiaView file viewer for Windows
Another Technique

- What if we used a radial rather than a rectangular space-filling technique?
Visualizing file and directory structures

Root dir at center
Color - file type
Angle - file/dir size
In large hierarchies, files at the periphery are usually tiny and very difficult to distinguish.
Fix: Objectives

- Make small slices bigger
- Maintain full circular space-filling idea
- Allow detailed examination of small files within context of entire hierarchy
- Don’t alter ratios of sizes

- Avoid use of multiple windows or lots of scrollbars
- Provide an aesthetically pleasing interface in which it is easy to track changes in focus
3 Solutions

- Three visualization+navigation techniques developed to help remedy the shortcoming
  - Angular detail
  - Detail outside
  - Detail inside

Stasko & Zhang

*Proceedings of Information Visualization 2000,*
Angular Detail

- Most “natural”
- Least space-efficient
- Most configurable by user
• Exhibits non-distorted miniature of overview
• Somewhat visually disconcerting
• Focus is quite enlarged (large circumference and 360°)
• Relatively space efficient
Perhaps least intuitive and most distorting

Items in overview are more distinct (larger circumference)

Interior 360° for focus is often sufficient
Good References

Books

1. *Readings in Information Visualization: Using Vision to Think*
   - Written and Edited by Stuart K. Card, Jock D. Mackinlay, Ben Shneiderman

2. *Information Visualization*
   - Robert Spence

3. *Envisioning Information*
   - Edward R. Tufte
Software Abounds


### Data visualization and analysis tools

<table>
<thead>
<tr>
<th>TOOL</th>
<th>CATEGORY</th>
<th>MULTI-PURPOSE VISUALIZATION</th>
<th>MAPPING</th>
<th>PLATFORM</th>
<th>SKILL LEVEL</th>
<th>DATA STORED OR PROCESSED</th>
<th>DESIGNED FOR WEB PUBLISHING?</th>
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<tbody>
<tr>
<td>OpenRefine (formerly Google Refine)</td>
<td>Data cleaning</td>
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<td>No</td>
<td>Browser</td>
<td>2</td>
<td>Local</td>
<td>No</td>
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<tr>
<td>R Project</td>
<td>Statistical analysis</td>
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<td>With plugin</td>
<td>Linux, Mac OS X, Unix, Windows XP or later</td>
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<td>Local</td>
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<tr>
<td>Google Fusion Tables</td>
<td>Visualization app/service</td>
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<td>Yes</td>
<td>Browser</td>
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<td>External server</td>
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<td>Tableau Public</td>
<td>Visualization app/service</td>
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<td>Windows, OS X</td>
<td>3</td>
<td>Public external server</td>
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<tr>
<td>VIDI</td>
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<td>External server</td>
<td>Yes</td>
</tr>
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</table>
Long History: IBM

IBM Many Eyes (now defunct)

http://www-958.ibm.com/software/data/cognos/manyeyes/
Interested in more...

- CS 7450

Course foci
- Look at research ideas
- Work with commercial systems
- Assignments and term project