Information Visualization in HCI

SWEN-444

Definitions

- **Visualize:**
  - To form a **mental model** or mental image of something
  - To **make something visible to the mind** or imagination
- **Visualization:**
  - **Human activit**y, not per se with computers
  - Visual, Auditory or other **sensory modalities**
  - Creation of **visual images** in aid of understanding of **complex**, data rich, **representations of data**

Information Visualization

- **Pre-attentive processing**
  - **Unconscious** accumulation of information from the environment
  - Information that "**stands out**" is selected for attentive (**conscious**) processing
  - Why does some information "stand out"?
    - Not exactly sure!
    - But it has something to do with the stimulus itself, and the person's current intentions or goals

Weber's law

- “just noticeable difference”

$$\frac{\Delta I}{I} = k$$

- I – original intensity of the stimulus
- Change in I is the minimum difference required for it to be perceived (jnd)
- K constant

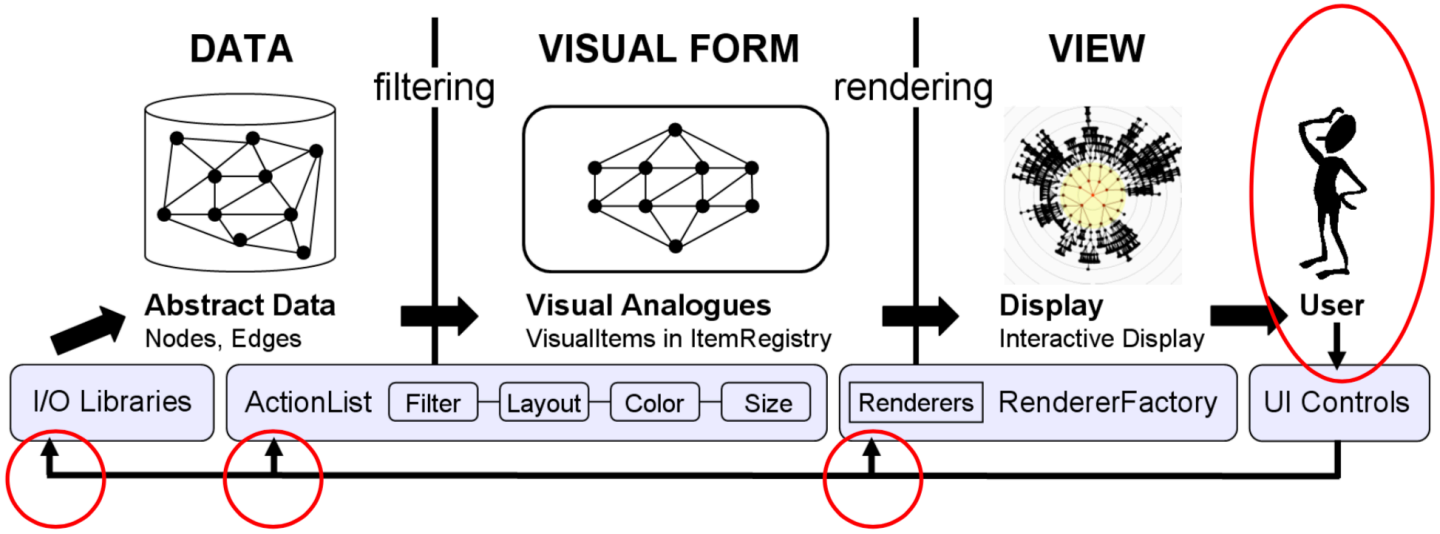
What is Information Visualization?

- Information visualization: "**the use of interactive visual representations of abstract data to amplify cognition"** (Ware, 2008)
- **Abstract data** include both **numerical and non-numerical data**
  - Stock prices, social relationships, patient records
- Typical concerns: **discovery** of patterns, trends, clusters, outliers and gaps in data
- Design goal: be more than aesthetically pleasing, **show measurable usability benefits** across different platforms and users

Information Visualization

- Data, dimensionality of the data
- Presentation of the data
- Processing of the data
- Interaction with the data
- Dynamical view updating

Information Visualization Flow



From de Heer et al, CHI 2005

HCI: disaster story

- 1988 :
- Iran Air Flight 655 shot down by USS Vincennes
- F-14?? - 290 casualties
- Conclusion: ‘Aegis had provided accurate data. The crew had misinterpreted it.’
- Different radar screens displayed different aspects of airplane
- Correlating information was difficult
- Vital data cluttered by trivial data

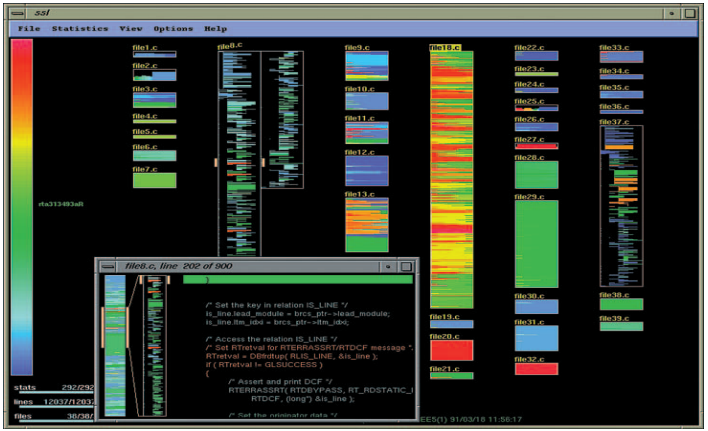
Data Type by Task Taxonomy

Data Types	
1D Linear	Document Lens, Seesoft™, Information Mural, TextArc
2D Map	Geographic information systems, ESRI ArcInfo™, ThemeView™, newspaper layout, self-organizing maps
3D World	Desktops, WebBook™, VRML™, Web3D™, architecture, computer-assisted design, medicine, molecules
Multidimensional	Parallel coordinates, scattergram matrices, hierarchical clustering, Spotfire®, Tableau®, GGobi®, DataDesk®, TableLens®, InfoZoom®
Temporal	DataMontage, Palantir, Project Managers, LifeLines, TimeSearcher
Tree	Outliners, degree-of-interest trees, cone/cam trees, hyperbolic trees, SpaceTree, treemaps
Network	NetMap™, netViz™, Pajek, JUNG, UCINet, NetDraw, TouchGraph, SocialAction, NodeXL

Tasks	
Overview	Gain an overview of the entire collection
Zoom	Zoom in on items of interest
Filter	Filter out uninteresting items
Details-on-demand	Select an item or group and get details when needed
Relate	View relationships among items
History	Keep a history of actions to support undo, replay, and progressive refinement
Extract	Allow extraction of subcollections and of the query parameters

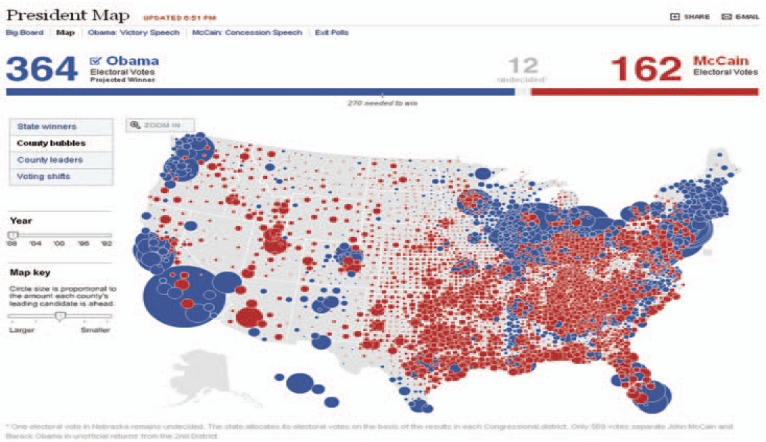
Data Type by Task Taxonomy: 1D Linear Data

- Items which can be **organized sequentially** e.g. text document, list of names
- Design issues:
  - Colors, sizes, layout
  - Scrolling, selection methods
- Example user tasks: check which items have some required attribute



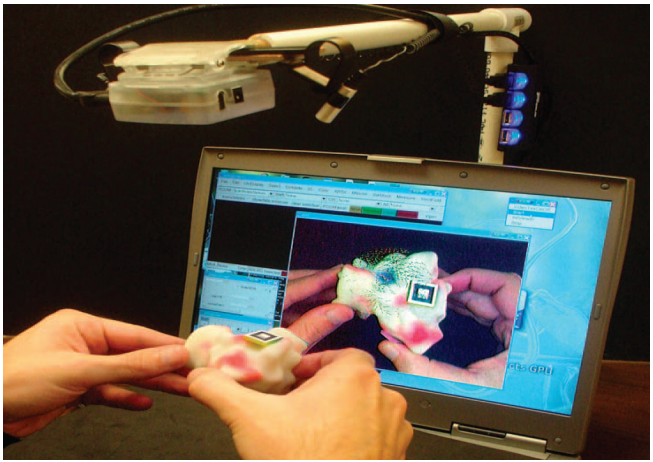
Data Type by Task Taxonomy: 2D Map Data

- **Items make up some part of the 2D area**
  - Not necessarily rectangular, e.g. Lake on Google Map
  - e.g. Geographic map, floor plans
- Example user tasks: finding items, finding paths between items



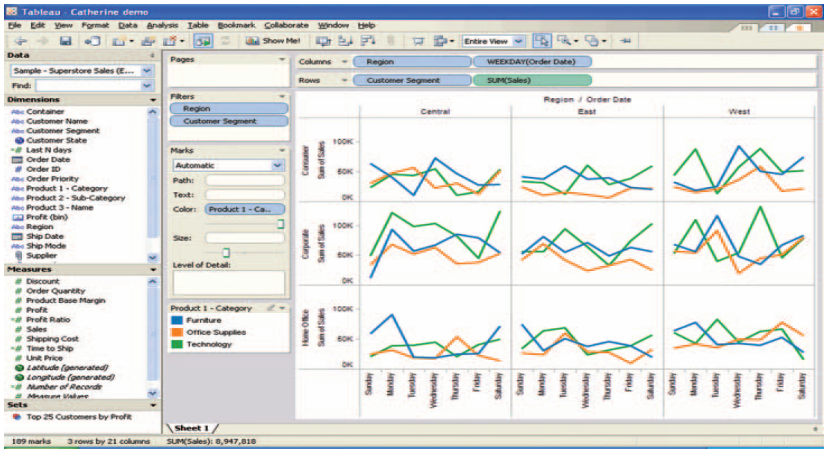
Data Type by Task Taxonomy: 3D World Data

- Items with **complex relationships** with other items
  - e.g. Volume, temperature, density
  - e.g. Medical imaging, architectural drawing, scientific simulations
- Design issues: position, orientation and navigation for viewing 3D application
- Example user tasks: temperature, density



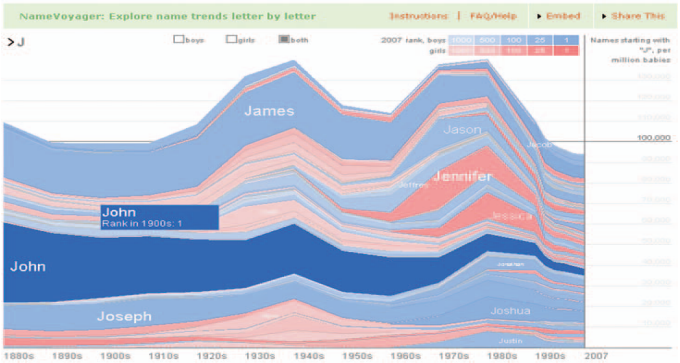
Data Type by Task Taxonomy: Multidimensional Data

- Items with **n attributes in n-dimensional space**
- Relational database contents can be treated this way
- Interface may allow user to view 2 dimensions at a time

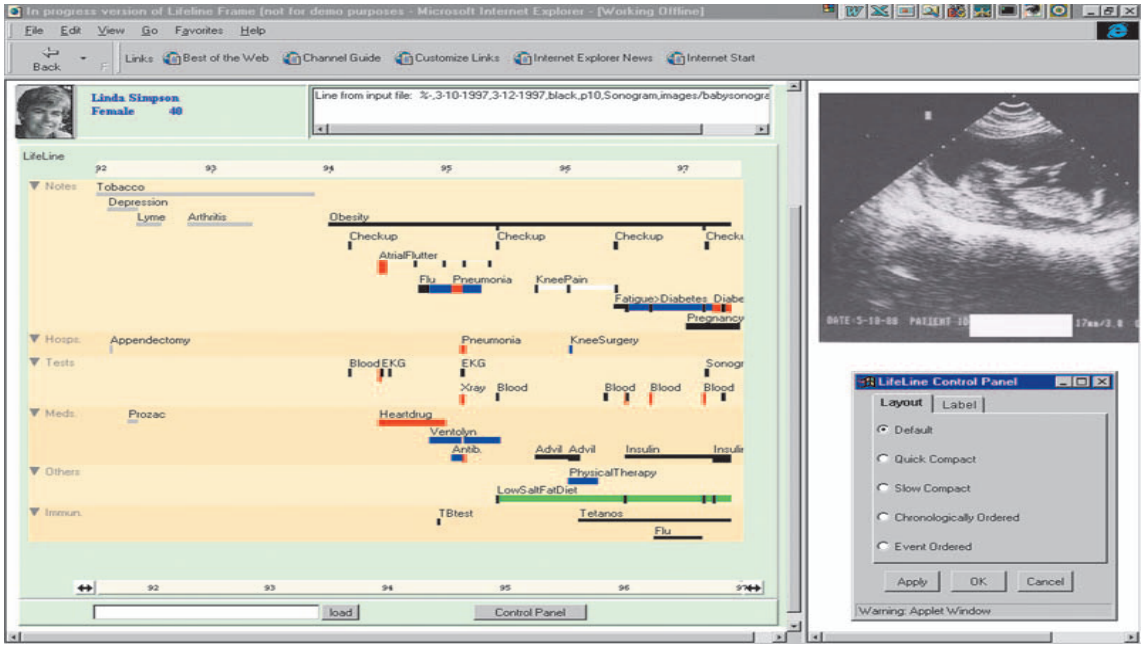


Data Type by Task Taxonomy: Temporal Data

- Very **close idea to 1D sequential data**, but warrant a distinct data type in the taxonomy as **temporal data** is so common
  - e.g. Stock market data, weather
- Items have a beginning and end time, may overlap in time
- Example user tasks: finding events during a time period, searching for periodical behavior

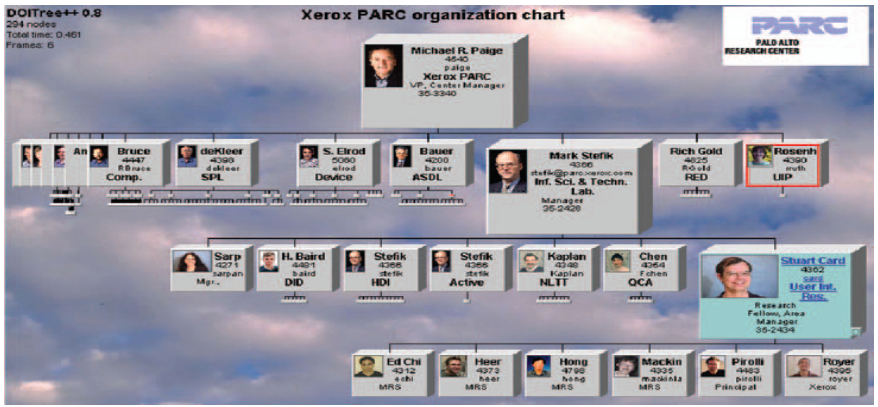


Data Type by Task Taxonomy: Temporal Data (cont.)

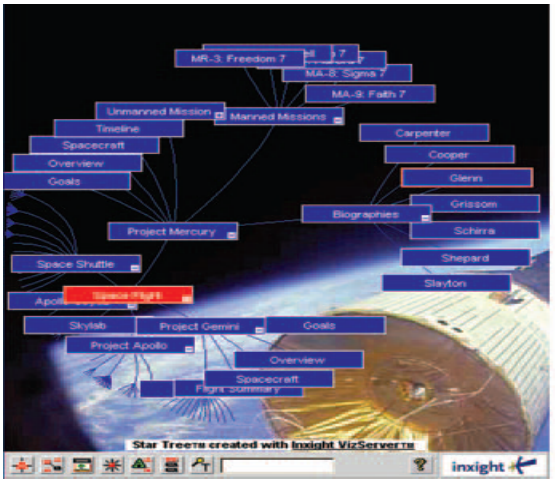


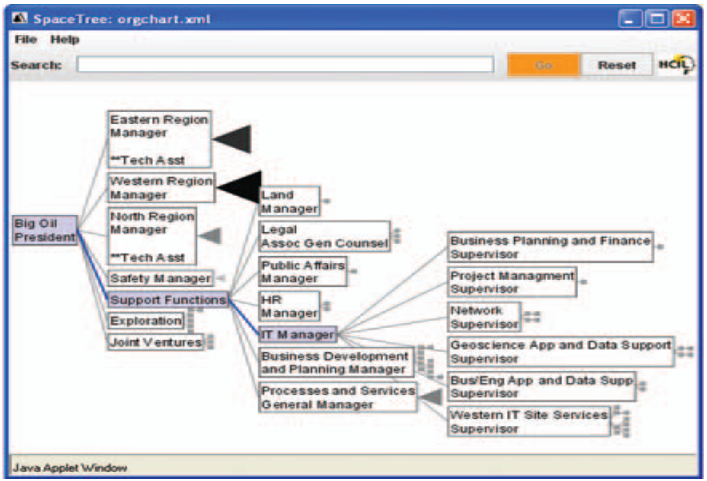
Data Type by Task Taxonomy: Tree Data

- Non-root items have a link to a parent item Items, links can have multiple attributes e.g. Windows file explorer
- Example user tasks: how many items are children of a node, how deep or shallow is the graph



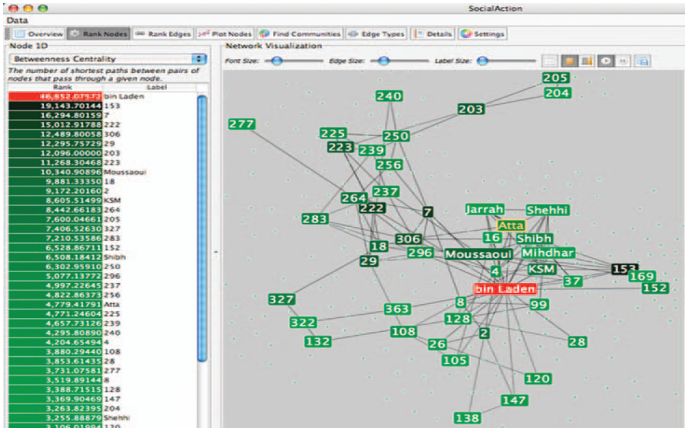
Data Type by Task Taxonomy: Tree Data (cont.)





Data Type by Task Taxonomy: Network Data

- **Items linked to arbitrary number of other items**
- Example user task: shortest path, least costly path
- How to visualize, layout the network?



The seven basic tasks

1. **Overview**: users can gain an overview of the entire collection
2. **Zoom**: users can zoom in on items of interest
3. **Filter**: users can filter out uninteresting items
4. **Details-on-demand**: users can select an item or group to get details
5. **Relate**: users can relate items or groups within the collection
6. **History**: users can keep a history of actions to support undo, replay, and progressive refinement
7. **Extract**: allow user to “save”, publish, examine extracted items

Challenges for Information Visualization

- **Importing** and **cleaning data**
- Combining visual representations with **textual labels**: How to put on text labels (e.g. on a map) without covering what you wish to display?
- **Finding related information**: Proper judgment often requires looking at data derived from multiple sources
- Viewing **large volumes of data**
- **Integrating data mining**
- **Integrating with analytical reasoning techniques**: Use data to support or disclaim hypotheses
- **Collaborating** with others
- Achieving **universal usability**: Text, tactile or sonic representations?
- **Evaluation**

Challenges for Information Visualization

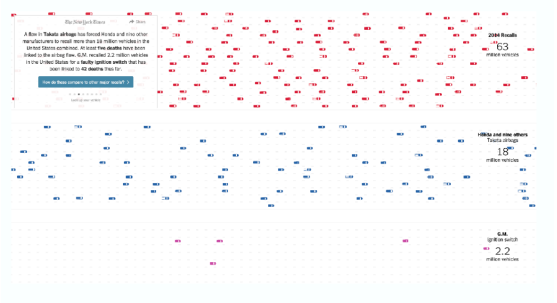
- Goal is to separate the "**signal** (information) **from the noise** (data)"
- **Too much** versus **too little** information
- Visualizations pass the **eyeball test**
- **Minimalism** – **emphasize** the **data rather than the scaffolding**
  - Avoid unnecessary and busy graphics
  - Readable size, legible
  - Appropriate use of color
  - Appropriate scaling, alignment, symmetry

Exercise: A Record Year for Auto Recalls

In discussion groups please answer the following questions:

- What is the data shown in this visualization?
- What questions does this visualization answer?
- What do you think about the use of animation?
- Is the visualization easy to understand?
- Can you read the data from the visualization?
- What is the visualization data type? What tasks can be performed?
- Why do you like / dislike this visualization?
- Can you suggest any improvements? How would you redesign it?

NY Times: http://bit.ly/auto-recall



References

- Folk, C.L., & Remington, R. Top-down modulation of preattentive processing: Testing the recovery account of contingent capture. Visual Cognition, 14, 445-465.
- Ware, Clin, *Visual Thinking for Design*, Morgan Kaufmann, San Francisco, CA (2008).
- http://www.cs.umd.edu/hcil/trs/96-13/96-13.html
- Cuffe, Kirkham, Dent, and Wilson, Data Visualization:The signal and the noise, IEEE Potentials July/August 2018