Visualization

- Presenting information visually to increase understanding

C.J. Minard, map drawn in 1869 showing plight of Napoleon's army in Russian campaign of 1812. (Popularized by E Tufte, The Visual Display of Quantitative Information)


Plots size of army, 2D location, direction of march, temperature during retreat
Visualization

- C.J. Minard, map showing plight of Napoleon’s army in Russian campaign of 1812. (Popularized by E Tufte, *The Visual Display of Quantitative Information*).

- “Visualization is a method of computing. It transforms the symbolic into the geometric, enabling researchers to observe their simulations and computations. Visualization offers a method for seeing the unseen…”

Richard Hamming observed many years ago that ‘The purpose of [scientific] computing is insight, not numbers.’ The goal of visualization is to leverage existing scientific methods by providing new scientific insight through visual methods.”

Information Visualization

- S. Card, J. Mackinlay, & G. Robertson, Xerox PARC, early 90’s
- Used “3D graphics workstations” to visualize data from fields other than science
  - Exploit human perceptual system
  - Present data that is not inherently spatial
- But, not just visual presentation
  - Audio, haptic, . . .

Visual Analytics

http://vis.pnnl.gov/

- “Addresses the issues faced by analysts, border personnel, and first responders”
- “Visual analytics is the science of analytical reasoning facilitated by interactive visual interfaces….”

Visual analytics is a multidisciplinary field that includes the following focus areas:
- Analytical reasoning techniques that enable users to obtain deep insights that directly support assessment, planning, and decision making
- Visual representations and interaction techniques that take advantage of the human eye’s broad bandwidth pathway into the mind to allow users to see, explore, and understand large amounts of information at once
- Data representations and transformations that convert all types of conflicting and dynamic data in ways that support visualization and analysis
- Techniques to support production, presentation, and dissemination of the results of an analysis to communicate information in the appropriate context to a variety of audiences.”

—J. Thomas and K. Cook (eds.), Illuminating the Path: The Research and Development Agenda for Visual Analytics, National Visualization and Analytics Center, 2005
Visual Information-Seeking Mantra

- “Overview first, zoom and filter, then details on demand” — B. Shneiderman

Data Types: 1D Linear

- Text
  - Documents
  - Source code
  - Lists

Techniques: Nonlinear Magnification

- In-place magnification of selected element(s) that preserves global context
  - Non-selected elements are typically minified
  - Level-of-detail is often changed along with size
- Related terms
  - Distortion viewing
  - Bifocal display
  - Fisheye views
  - Focus+context
    - Fisheye and focus+context also refer to techniques that do not magnify, but do change level-of-detail

R. Spence and M.D. Apperley, Bifocal display, 1982
https://www.youtube.com/watch?v=RN32XUqJP4

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https://www.youtube.com/watch?v=30X51fsm1Zo
Fisheye Views  G. Furnas, CHI 86

- Address limited screen space with level-of-detail analogy to photographic fisheye lens
- Balance local detail with global context

G. Furnas, Generalized fisheye views, CHI 86
G. Furnas, A fisheye followup: Further reflections on focus + context, CHI 06

S. Steinberg, 1976
Fisheye Views G. Furnas, CHI 86

- **Compute Degree of Interest (DOI)**
  - Assign a value to each element in a structure, indicating its interest to the user, given the current task
- **Create display**
  - Present top $n$ elements by choosing $n$ with highest DOI
- **So, how to define DOI?**

\[
\text{DOI}_{FE}(x | .= y) = \text{API}(x) - D(x,y)
\]

- $\text{DOI}_{FE}(x | .= y)$ is **degree of interest** in element $x$, given that the current element of **focus** is $y$
- $\text{API}(x)$ is global **a priori importance** of $x$
- $D(x,y)$ is **distance** between $x$ and $y$
- Degree of interest increases with **a priori** importance and decreases with distance to $y$
- Given $k$, display only $x$ where $\text{DOI}_{FE}(x | .= y) \geq k$
- $k$ determines # elements in fisheye view
Fisheye Views G. Furnas, CHI 86

- Difference from optical fisheye lens
  - **Select** (what to show) rather than **distort** (how to show)
  - Other work (sometimes called fisheye, too) emphasizes distortion
  - Distortion (scaling larger/smaller) also affects what is shown
    - Scaling smaller decreases legibility
  - Distortion can be used as a companion technique
- **Distance** is not necessarily geometric

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Fisheye Views G. Furnas, CHI 86

- $\text{DOI}_{FE}(x |.= y) = \text{API}(x) - D(x,y)$
- Example: For a tree visualization
  - $\text{API}(x) = -d_{\text{tree}}(x,\text{root})$
    - Negative of the path length between $x$ and root
      (farthest from root = least important)
**Fisheye Views** G. Furnas, CHI 86

- **DOI**$_{FE}(x \mid .= y) = API(x) - D(x,y)$
- Example: For a tree visualization
  - $D(x,y) = d_{tree}(x,y)$
    - Path length between $x$ and $y$ (where $y$ is the focus)

```
1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1

y  "focus"```

- **DOI$_{FE}$(tree)$\mid .= y) = -d_{tree}(x,root) - d_{tree}(x,y)$
  - $= -(d_{tree}(x,root)+d_{tree}(x,y))$

```
-1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1
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Fisheye Views  G. Furnas, CHI 86

- $\text{DOI}_{FE}(x |.= y) = \text{API}(x) - D(x,y)$
- Given $k$, display only $x$ where $\text{DOI}_{FE}(x) \geq k$
  - Creates fisheye views of different sizes
    - Zero-order tree fisheye ($k = -3$)

We can also redraw the tree.
Fisheye Views  G. Furnas, CHI 86

- $\text{DOI}_{FE}(x \mid y) = \text{API}(x) - D(x, y)$
- Given $k$, display only $x$ where $\text{DOI}_{FE}(x) \geq k$
  - Creates fisheye views of different sizes
    - Zero-order tree fisheye ($k = -3$)

![Diagram](image1)

Fisheye Views  G. Furnas, CHI 86

- $\text{DOI}_{FE}(x \mid y) = \text{API}(x) - D(x, y)$
- Given $k$, display only $x$ where $\text{DOI}_{FE}(x) \geq k$
  - Creates fisheye views of different sizes
    - First-order tree fisheye ($k = -5$)

![Diagram](image2)
**Fisheye Views** G. Furnas, CHI 86

- DOI\(_{FE}(x \neq y) = API(x) - D(x,y)
- Given \( k \), display only \( x \) where DOI\(_{FE}(x) \geq k\)
  - Creates fisheye views of different sizes
  - Second-order tree fisheye (\( k = -7 \))

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**Generalizing Fisheye Views**

G. Furnas, CHI 06

- **What to show**
  - DOI\(_{FE}\)
- **How to show**
  - E.g., distortion of position and scale
  - How can also influence what through legibility!

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Feiner, COMS W4170, Fall 2015