CS W4170
Information Visualization

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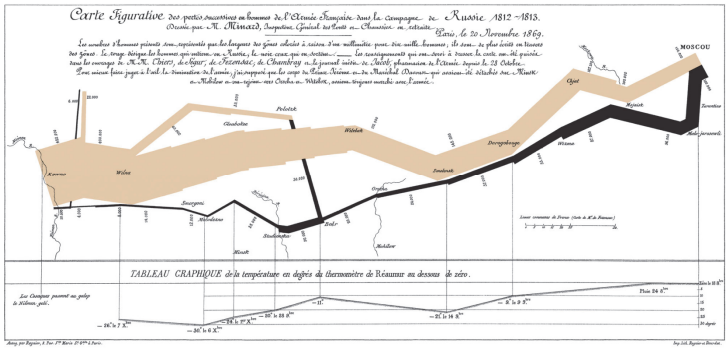
Visualization

- Presenting information visually to increase understanding

http://en.wikipedia.org/wiki/File:Minard.png

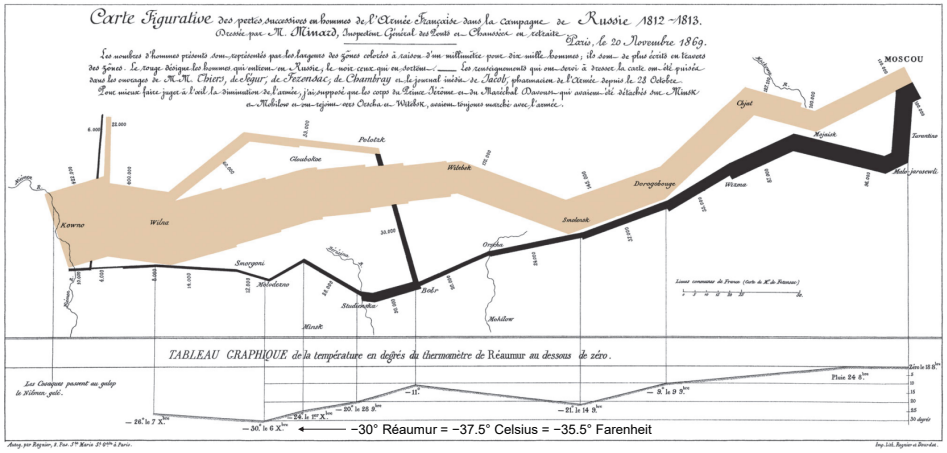


C.J. Minard drew this map in 1869 to show plight of Napoleon's army in Russian campaign of 1812. (Popularized by E Tufte, *The Visual Display of Quantitative Information*)

Plots against time: size of army, 2D location, direction of march, temperature during retreat

Visualization

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



Plots against time: size of army, 2D location, direction of march, temperature during retreat

Scientific Visualization

One of 3 main subfields of Visualization

- "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…

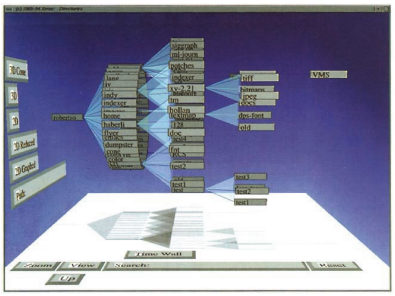
  Richard Hamming observed many years ago that '*The purpose of [scientific] computing is insight, not* numbers.' The goal of visualization is to leverage existing scientific methods by providing new scientific insight through visual methods."

  — B. McCormick, T. DeFanti, and M. Brown, *Visualization in Scientific Computing, Computer Graphics*, 21(6), November 1987

Information Visualization

One of 3 main subfields of Visualization

- S. Card, J. Mackinlay, & G. Robertson, Xerox PARC, early 90s
- 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, . . .



http://dl.acm.org/citation.cfm?id=108883

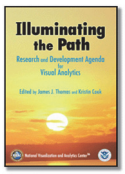
Visual Analytics

One of 3 main subfields of Visualization

- "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



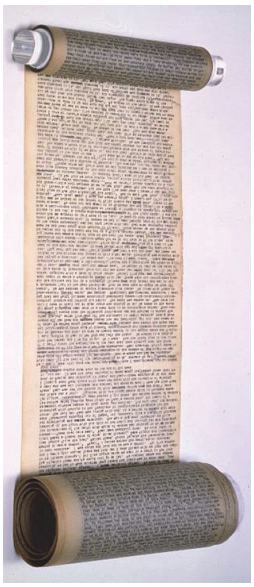
https://www.hsdl.org/?abstract&did=485291

Visual Information-Seeking Mantra

- *"**Overview** first, **zoom** and **filter**, then **details on demand**" — B. Shneiderman*

Data Types: 1D Linear

- Text
  - Documents
  - Source code
  - Lists

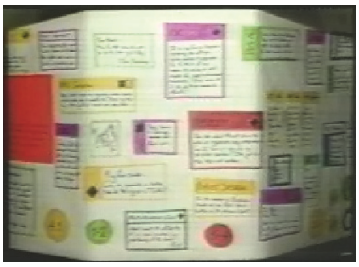


http://www.npr.org/templates/story/story.php?storyId=11709924

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

Paper prototype



R. Spence and M.D. Apperley, Bifocal display, 1982
https://www.youtube.com/watch?v=RN3Z4XojDP4

https://www.interaction-design.org/literature/book/the-encyclopedia-of-human-computer-interaction-2nd-ed/bifocal-display

Techniques: Nonlinear Magnification

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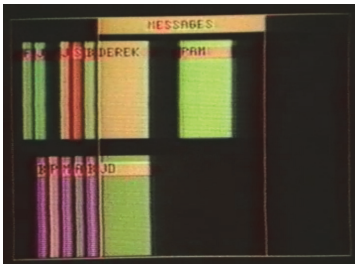
- Related terms
  - *Distortion viewing*
  - *Bifocal display*
  - *Fisheye views*
  - *Focus+context*
    - Fisheye and focus+context also refer to techniques that do not magnify geometrically, but do change level-of-detail

Hifi prototype



R. Spence and M.D. Apperley, Bifocal display, 1982
https://www.youtube.com/watch?v=30X51fsm1Zo

https://www.interaction-design.org/literature/book/the-encyclopedia-of-human-computer-interaction-2nd-ed/bifocal-display

Fisheye Views *G. Furnas, CHI 86*

- Address limited screen space with level-of-detail analogy to photographic fisheye lens (often without geometric distortion)
- 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*

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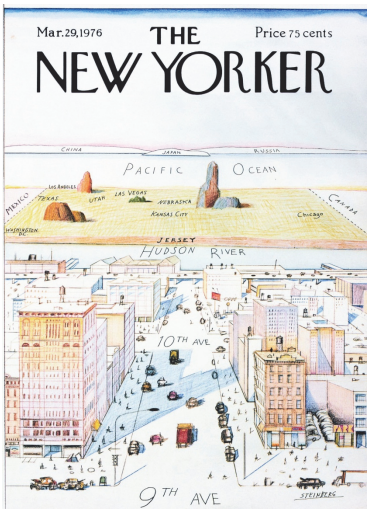

S. Steinberg, 1976

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?

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Fisheye Views *G. Furnas, CHI 86*

- $\mathbf{DOI}_{FE}(x \mid .= y) = \mathbf{API}(x) - \mathbf{D}(x,y)$
  - $\mathbf{DOI}_{FE}(x \mid .= y)$ is **degree of interest** in element *x*, given that the current element of **focus** is *y*
  - **API**(*x*) is global ***a priori* importance** of *x*
  - **D**(*x,y*) is **distance** between *x* and *y*
  - Degree of interest in *x* increases with *a priori* importance and decreases with distance to *y*
- Given threshold *k*, display only *x* for which $\mathbf{DOI}_{FE}(x \mid .= y) \geq k$
  - *k* determines # elements in fisheye view

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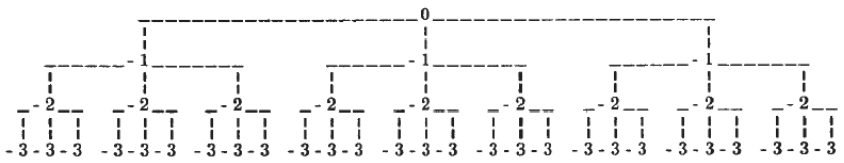
Fisheye Views *G. Furnas, CHI 86*

- Difference from optical fisheye lens

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

Fisheye Views *G. Furnas, CHI 86*

- $\mathbf{DOI}_{FE}(x \mid .= y) = \mathbf{API}(x) - \mathbf{D}(x,y)$
- Example: For a tree visualization
  - $\mathbf{API}(x) = -d_{tree}(x,\text{root})$
    - Negative of the path length between *x* and root
      (farther from root → less important)



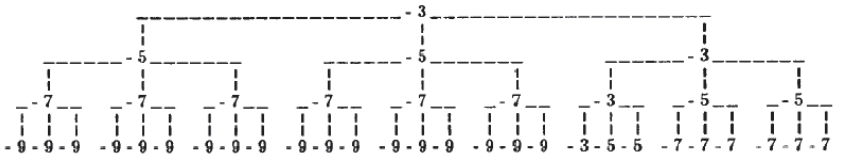
Fisheye Views *G. Furnas, CHI 86*

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

y
"focus"

Fisheye Views *G. Furnas, CHI 86*

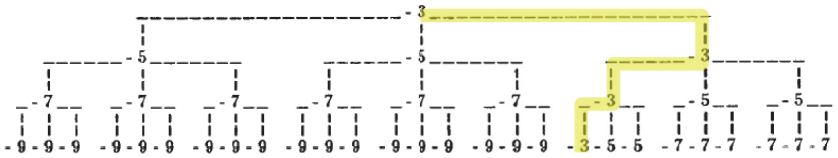
- $\mathbf{DOI}_{FE}(x \mid .= y) = \mathbf{API}(x) - \mathbf{D}(x,y)$
- Example: For a tree visualization
  - $\mathbf{DOI}_{FE(tree)}(x \mid .= y) = -d_{tree}(x,\text{root}) - d_{tree}(x,y)$
    $= -(d_{tree}(x,\text{root}) + d_{tree}(x,y))$



y
"focus"

Fisheye Views *G. Furnas, CHI 86*

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



y
"focus"

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- $\mathbf{DOI}_{FE}(x \mid .= y) = \mathbf{API}(x) - \mathbf{D}(x,y)$
- Given k, display only x where $\mathbf{DOI}_{FE}(x) \geq k$
  - Creates fisheye views of different sizes
    - Zero-order tree fisheye ($k = -3$)
    - We can also redraw the tree, ignoring original layout

y
"focus"

Fisheye Views *G. Furnas, CHI 86*

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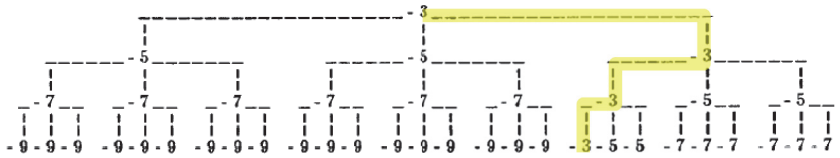

y
"focus"

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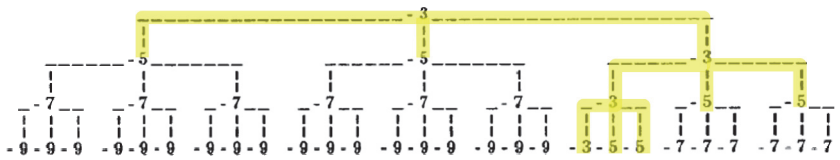
Fisheye Views *G. Furnas, CHI 86*

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

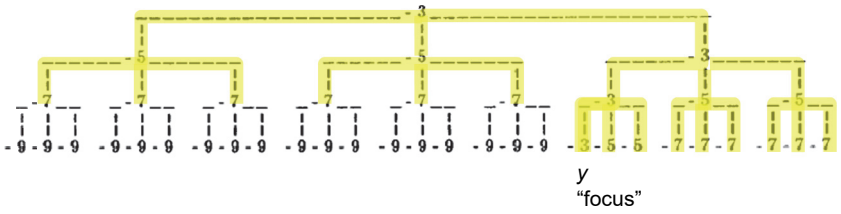


y
"focus"

22

Fisheye Views *G. Furnas, CHI 86*

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



y
"focus"

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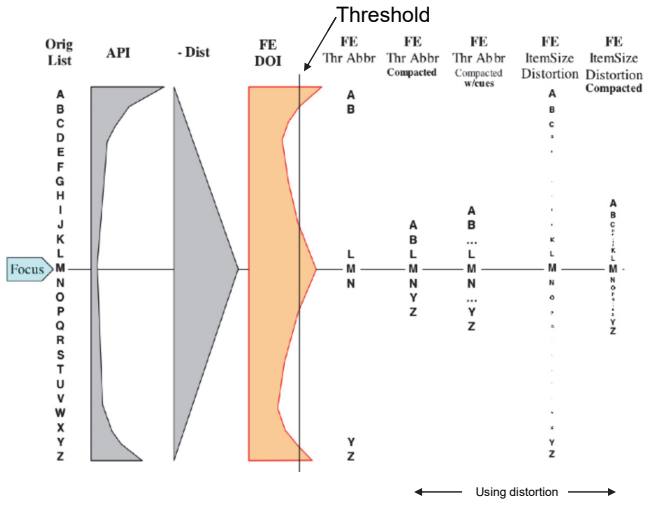
Generalizing Fisheye Views

G. Furnas, CHI 06

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



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