1

TREES AND HIERARCHIES

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  - Dr. Abish Malik (Purdue)
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  - Dr. Ross Maciejewski (ASU)
  - Dr. Niklas Elmqvist (UMD)
  - Dr. David Ebert (Purdue)

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Hierarchies

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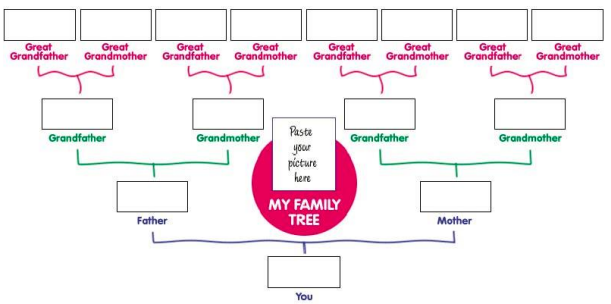
- Definition
  - Data repository in which cases are related to subcases
  - Can be thought of as imposing an ordering in which cases are parents or ancestors of other cases



Parts of this slide borrowed from John Stasko's Information Visualization Course Lecture: Hierarchies and Trees 1(Node-Link): http://www.cc.gatech.edu/~stasko/7450/11s/Talks/tree1.pdf

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Trees

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- In the last lectures we've been discussing Graphs
- Hierarchies are often represented as trees
  - Directed
  - Acyclic
- Two main representation schemes
  - Node-link (this is similar to the graphical representations we've discussed earlier)
  - Space-Filling

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Rooted Trees

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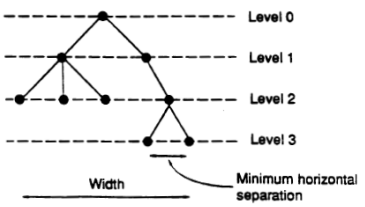
- A graph might be used to represent some hierarchy, so we often utilize a tree metaphor
- Typically, these utilize the following aesthetics
  - Vertices are placed along horizontal lines according to their level (distance from root)
  - There is a minimum separation distance between two consecutive vertices on the same level
  - The width of the drawing is as small as possible



P Eades and R Tamassia, "Algorithms for Drawing Graphs: An Annotated Bibliography," *Technical Report No. CS-89-09*, Brown University, October 1989.

5

Using Rooted Trees

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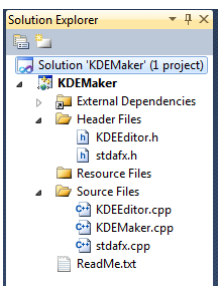
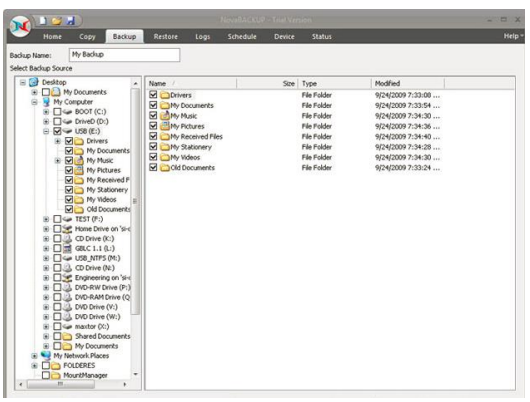
- What are such sorts of structures useful for?





6

Top-Down Approach

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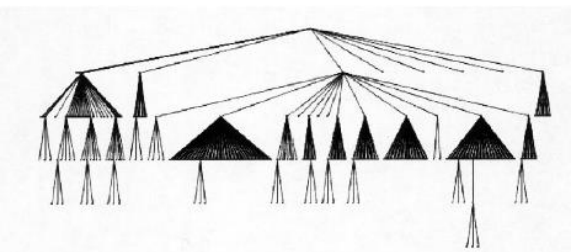
- Width of fan-out uses up horizontal real estate very quickly
  - At level n, there are 2^n nodes
- Tree may grow very long in one branch
- Essentially you can wind up leaving a lot of screen real estate empty



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Space Tree

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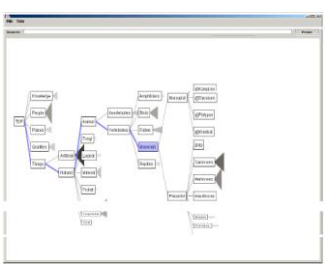
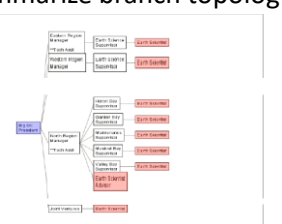
- Visualization techniques try to overcome some of these issues in node link tree diagrams
- *Space Tree* by Plaisant et al.
  - Dynamic rescaling of branches to best fit available screen space
  - Utilized preview icons to summarize branch topology





https://www.jasondavies.com/wordtree/?source=cat-in-the-hat.txt&prefix=Thing

Plaisant, C.; Grosjean, J.; Bederson, B.B.; , "SpaceTree: supporting exploration in large node link tree, design evolution and empirical evaluation," *IEEE Symposium on Information Visualization*, pp. 57- 64, 2002

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Cone Trees

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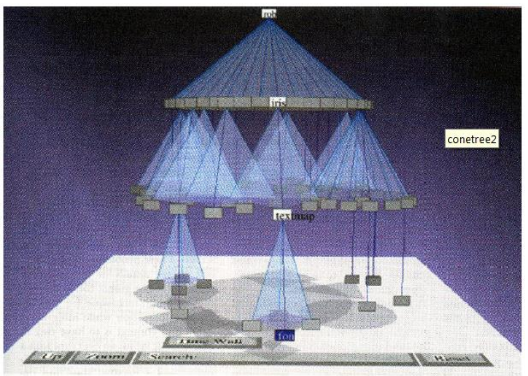
- Add a third dimension for the layout
- Children of a node are laid out in a cylinder below the parent
  - Siblings live in one of the 2D planes



Robertson, G. G. Mackinlay, J. D. Card, S. K. Cone Trees: animated 3D visualizations of hierarchical information, *Proc. Human factors in computing systems conference,* March 1991, 189-194.

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Hyperbolic Trees

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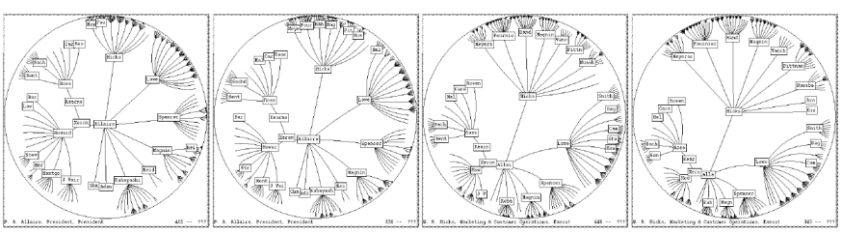
- We don't have to constrain ourselves to the top-down geometry approach
- We can apply a hyperbolic transformation to the space
- Distance between parent and child decreases as you move farther from the center
- Children go in a wedge rather than a circle



Lamping, J., Rao, R., Pirolli; P. (1995) A focus+context technique based on hyperbolic geometry for visualizing large hierarchies *Conference proceedings on Human factors in computing systems*, 1995, 401-408

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Space-Filling Representation

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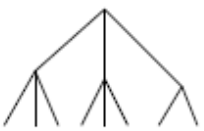
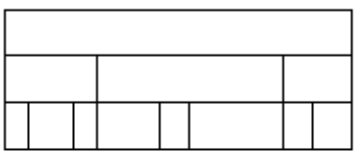
- Each item now occupies an area
- Children are contained under the parent





One example: "Icicle plot"

Parts of this slide borrowed from John Stasko's Information Visualization Course Lecture: Hierarchies and Trees 2(Space Filling): http://www.cc.gatech.edu/~stasko/7450/Notes/tree2.pdf

Treemap

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- Space filling representation developed by Johnson and Shneiderman
- Children are drawn inside their parent
- Alternate horizontal and vertical slicing at each successive level
- Use area to encode other variable of data items

Johnson, B. and Shneiderman, B. Treemaps: A Space-Filling Approach to the Visualization of Hierarchical Information Structures. In Proceedings of the IEEE Information Visualization '91, pages 275–282, IEEE, 1991.

Treemap Algorithm

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Draw()
{
1) Change orientation from parent (horiz/vert)
2) Read all files and directories at this level
3) Make rectangles for each, scaled to size
4) Draw rectangles using appropriate size and color
5) For each directory
a) Make recursive call using its rectangle as focus
}

Parts of this slide borrowed from John Stasko's Information Visualization Course Lecture: Hierarchies and Trees 2(Space Filling): http://www.cc.gatech.edu/~stasko/7450/Notes/tree2.pdf

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Nested vs. Non-Nested

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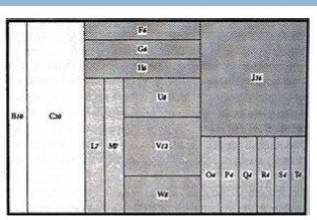
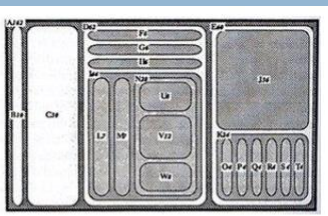
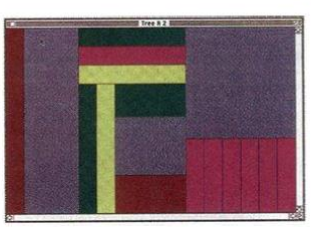
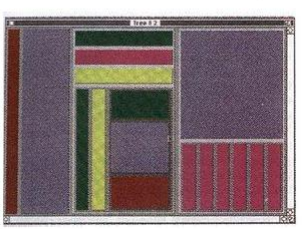


Non-nested Tree-Map



Nested Tree-Map





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Treemap Applications

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- Can use the Treemap idea in a variety of domains
  - File/directory structures
  - Software diagrams
  - Sports analysis
  - Stock market data
- Examples
  - http://www.bewitched.com/marketmap.html
  - https://finviz.com/map.ashx

Parts of this slide borrowed from John Stasko's Information Visualization Course Lecture: Hierarchies and Trees 2(Space Filling): http://www.cc.gatech.edu/~stasko/7450/Notes/tree2.pdf

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Treemap Benefits

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- Good representation of two attributes beyond node-link: color and area
- Not quite as good at representing structure
  - For example, what happens if the tree is perfectly balanced?
  - Can also get long-thin aspect ratios
  - Borders can help on small trees, but take up too much area on large, deep trees

Parts of this slide borrowed from John Stasko's Information Visualization Course Lecture: Hierarchies and Trees 2(Space Filling): http://www.cc.gatech.edu/~stasko/7450/Notes/tree2.pdf

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Aspect Ratios

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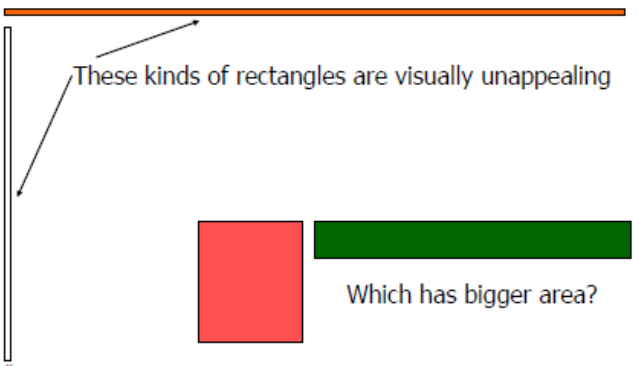
- Here, the aspect ratio will drastically affect the visualization



Parts of this slide borrowed from John Stasko's Information Visualization Course Lecture: Hierarchies and Trees 2(Space Filling): http://www.cc.gatech.edu/~stasko/7450/Notes/tree2.pdf

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"Clustered and Squarified Treemaps

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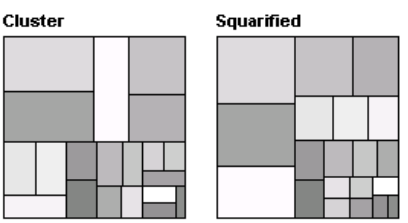
- http://www.bewitched.com/marketmap.html
- This treemap uses a simple recursive algorithm to reduce the overall aspect ratio
- Bruls et al. introduced the squarified treemap
  - utilized a different algorithm to also try to utilize the aspect ratio



1 -Wattenberg, M. "Visualizing the Stock Market," *Proceedings of ACM CHI 99, Extended Abstracts,* pp.188-189, 1999.
2 -Bruls, D.M., C. Huizing, J.J. van Wijk. "Squarified Treemaps". In: W. de Leeuw, R. van Liere (eds.), *Data Visualization 2000. Proceedings of the joint Eurographics and IEEE TCVG Symposium on Visualization*, 2000, pp. 33-42.

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Clustered and Squarified Treemaps

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- Methods had two major drawbacks
  - Changes in the set can cause discontinuities in the layout
    - ??
  - Ordering information
    - ??

1 -Wattenberg, M. "Visualizing the Stock Market," *Proceedings of ACM CHI 99, Extended Abstracts,* pp.188-189, 1999
2 -Bruls, D.M., C. Huizing, J.J. van Wijk. "Squarified Treemaps". In: W. de Leeuw, R. van Liere (eds.), *Data Visualization 2000: Proceedings of the joint Eurographics and IEEE TCVG Symposium on Visualization*, 2000, pp. 33-42.

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Ordered Treemap

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- Shneiderman and Wattenberg introduced the ordered treemap to try and overcome these limitations
- Key insight is that it's possible to create a layout in which items that are next to each other in the given order are adjacent in the tree map
- Presented two algorithms for ordering a treemap
  - Pivot-by-size: the largest area-> most difficult to place
  - Pivot-by-middle: may create a balance layout

Ben Shneiderman, Martin Wattenberg: Ordered Treemap Layouts. INFOVIS 2001: 73-78

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Metrics For Treemaps

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- In order to assess all these different treemap algorithms, we need metrics to define how “good” they are
- Use two metrics:
  - Average ?? of treemap layout
  - Layout distance change function
- Goal is to have ?? and a ?? as data is updated
- Average aspect ratio is the unweighted average
- Distance change is Euclidian distance of change in width height and corner location of rectangles

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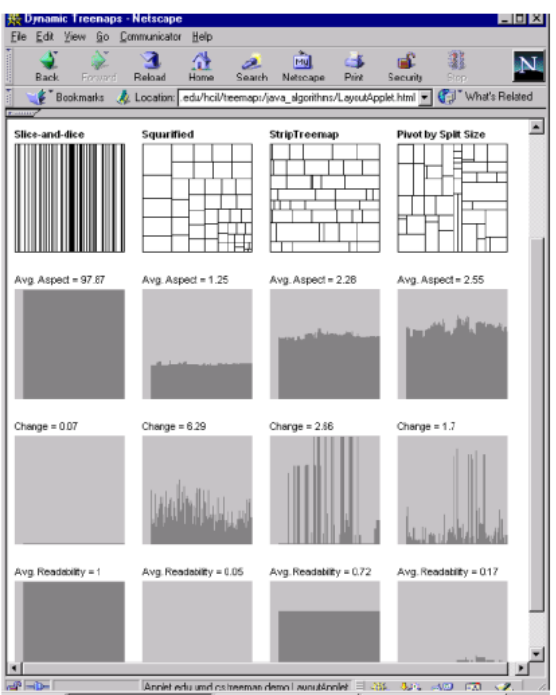

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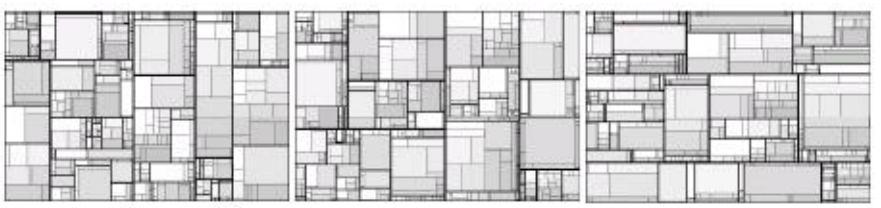

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Another Problem

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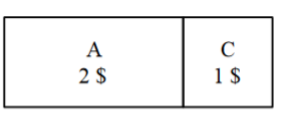
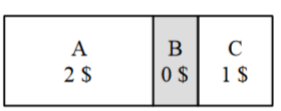
- What if nodes with zero value are very important?
- If we're mapping areas, how do we map to zero
  - Example: Stocks portfolios, I want to know what I'm not investing in because I may potentially invest



Classic Treemap
Preserves value proportions



Context Treemap
Distorts value proportions to preserve identity

Parts of this slide borrowed from John Stasko's Information Visualization Course Lecture: Hierarchies and Trees 2(Space Filling): http://www.cc.gatech.edu/~stasko/7450/Notes/tree2.pdf

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Context Treemap

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- One way to overcome this is to distort the classic treemap visualization
- Distorted treemap can show one more attribute than a classic treemap, but node area is no longer proportional to the attribute being visualized
- Several different implementation strategies for this
  1. Use a regular tree map but add some epsilon to zero value items
     - Unfortunately, as tree grows this causes things to get squished
  2. Use an exponential mapping area(node)=2^(value(node))
  3. Assign some minimal screen space size to zero nodes

Christoph Csallner, Marcus Handte, Othmar Lehmann, John T. Stasko: FundExplorer: Supporting the Diversification of Mutual Fund Portfolios Using Context Treemaps. INFOVIS 2003: 203-208

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Context Treemap

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- Final solution was to calculate intermediate values

1. Calculate the total (in this paper it was total invest money)
   - Value(total)
2. Create an additional total with respect to the context
   - Value(total)*v, where v can be modified as a scale factor
3. Split context screen real estate among all empty nodes
   - $Value_c$ = value(total)*v/#empty

$$value`(node) = \begin{cases} value_c & \text{if } value(node) = 0 \\ value(node) & \text{otherwise} \end{cases}$$

Christoph Csallner, Marcus Handte, Othmar Lehmann, John T. Stasko: FundExplorer: Supporting the Diversification of Mutual Fund Portfolios Using Context Treemaps. INFOVIS 2003: 203-208

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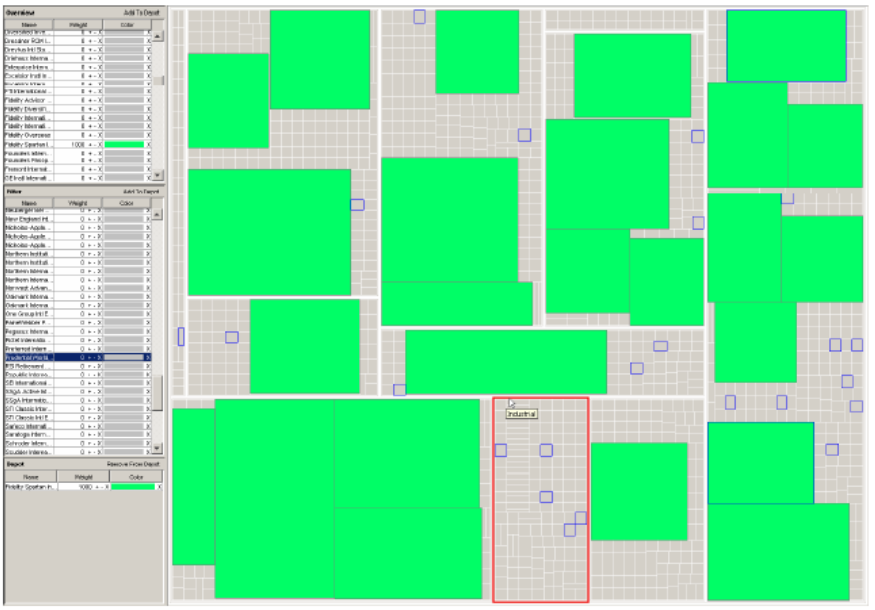

Christoph Csallner, Marcus Handte, Othmar Lehmann, John T. Stasko: FundExplorer: Supporting the Diversification of Mutual Fund Portfolios Using Context Treemaps. INFOVIS 2003: 203-208

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Circle Packing

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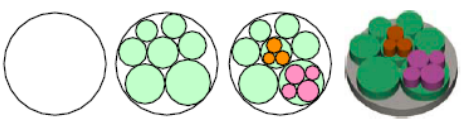

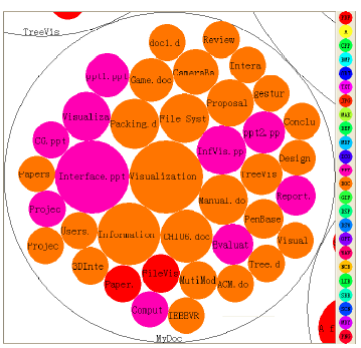

Weixin Wang, Hui Wang, Guozhong Dai, and Hongan Wang. 2006. Visualization of large hierarchical data by circle packing. In *Proceedings of the SIGCHI conference on Human Factors in computing systems* (CHI '06), pg. 517-520.

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Applications

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- http://www.cs.umd.edu/hcil/treemap-history/index.shtml

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Readings

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- Required Reading:
  - B. Johnson and B. Shneiderman, "Tree-maps: A Space Filling Approach to the Visualization of Hierarchical Information Structures", Proc. of Vis '91, Oct. 1991, pp. 284-291.
  - B. Bederson, B. Shneiderman, and M. Wattenberg, Ordered and Quantum Treemaps: Making Effective Use of 2D Space to Display Hierarchies, *ACM Trans. on Graphics*, Vol. 21, No. 4, Oct. 2002, pp. 833-854.
  - **Perceptual Guidelines for Creating Rectangular Treemaps**, Nicholas Kong, Jeffrey Heer and Maneesh Agrawala. *IEEE Transactions on Visualization and Computer Graphics (Proc. InfoVis'10)*, Oct 2010.

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