Topic Notes

Hierarchies and Trees 2 (Space-filling)

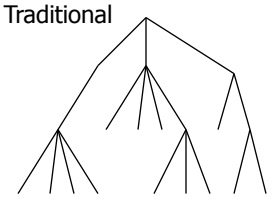
CS 7450 - Information Visualization
October 30, 2013
John Stasko

Hierarchies Recall

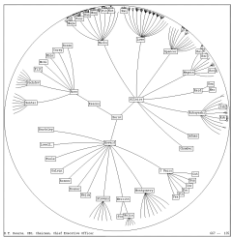
- Definition
  - Data repository in which cases are related to subcases
  - Can be thought of as imposing an ordering in which cases are parents or ancestors of other cases

Last Time: Node-Link Reps

Traditional

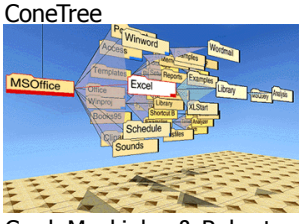


Hyperbolic tree



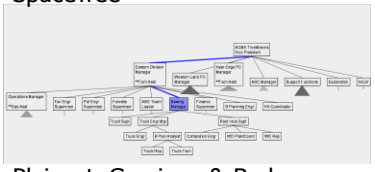
Lamping & Rao

ConeTree



Card, Mackinlay & Robertson

SpaceTree



Plaisant, Grosjean & Bederson

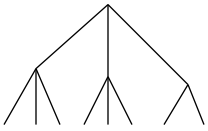
Node-link Shortcoming

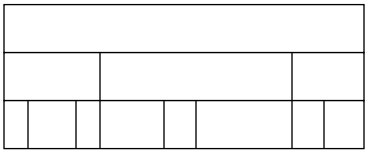
- Difficult to encode more variables of data cases (nodes)
  - Shape
  - Color
  - Size
  - …but all quickly clash with basic node-link structure

Space-Filling Representation

Each item occupies an area

Children are "contained" under parent



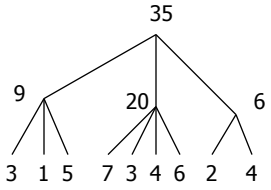


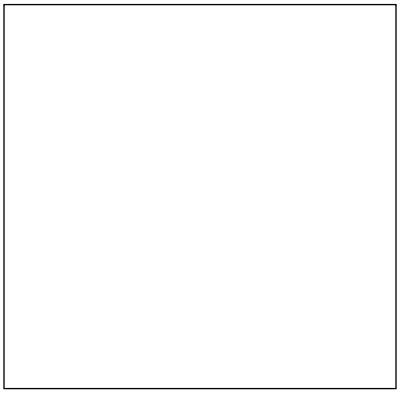
One example: "Icicle plot"

Treemap

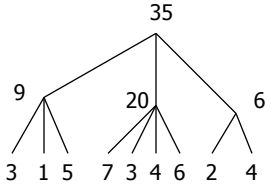
- Space-filling representation developed by Shneiderman and Johnson, Vis '91
- Children are drawn inside their parent
- Alternate horizontal and vertical slicing at each successive level
- Use area to encode other variable of data items

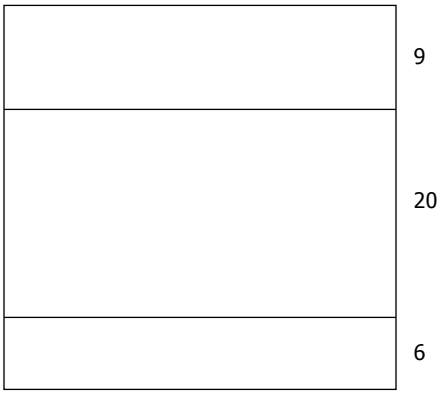
Example



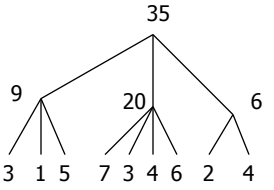


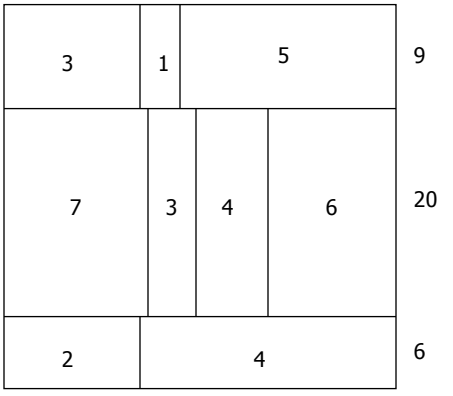
Example





Example

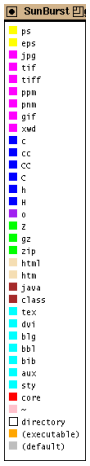


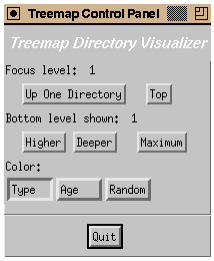


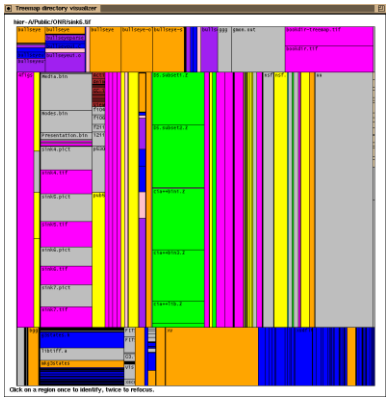
Treemap

- Example

Treemap Example





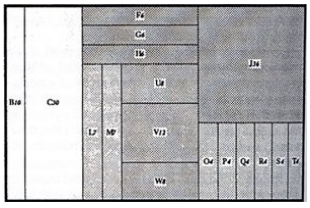


Old one I built for our Sun workstations

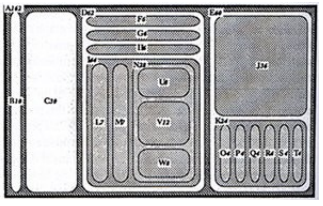
Treemap Algorithm

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

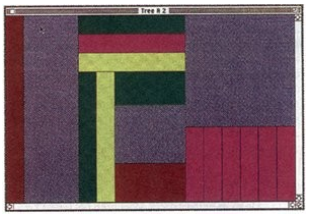
Nested vs. Non-nested

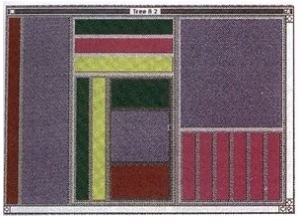


Non-nested Tree-Map



Nested Tree-Map





Applications

- Can use Treemap idea for a variety of domains
  - File/directory structures
  - Basketball statistics
  - Software diagrams
  - Tennis matches

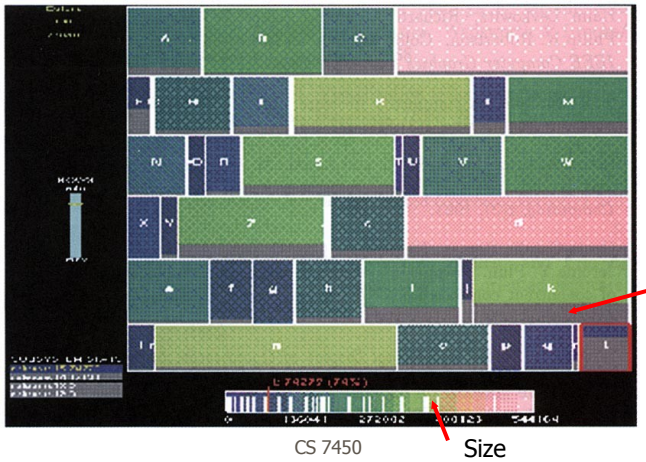
Software Visualization App

- SeeSys: Software Metrics Visualizing System
- Uses treemap-like visualization to present different software metrics
- Displays:
  - Size
  - Recent development
  - High fix-on-fix rates
  - History and growth

Baker and Eick
JVLC '95

Sample View 1

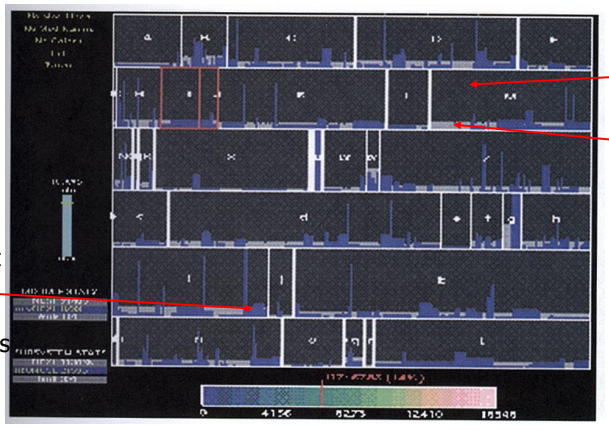
Subsystems in a software system. Each rectangle represents the non-comment source code in a subsystem. Area means size



Sample View 2

Bug rates by subsystem and directory

Represents new code in this release



Added functionality

Bug fixes

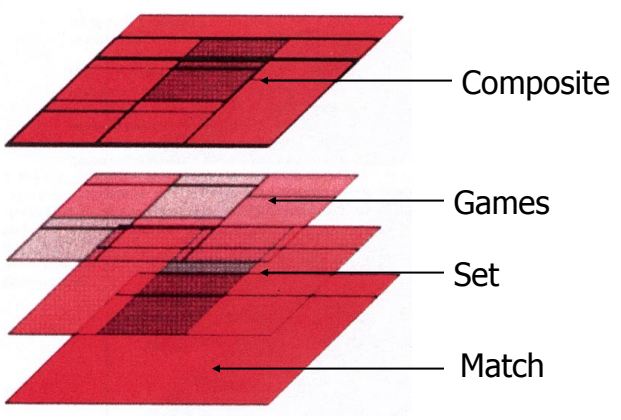
Bars represent individual directories in the subsystems

Tennis Viewing Application

- Analyze, review and browse a tennis match
- Space-filling/treemap-like hierarchy representation for a competition tree
- Shows match,sets,games,points
- Uses lenses to show shot patterns
- Red/green to encode two players
- Composite colors on top of each other

Jin and Banks
IEEE CG&A '97

Visualization Make-up



Simulated Match Results

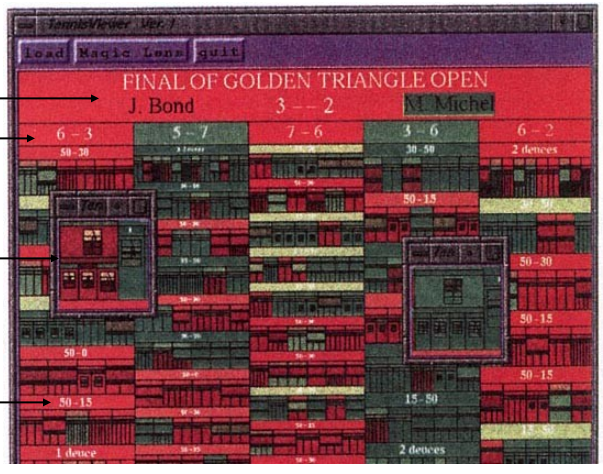
Match view

Bond won

Set results

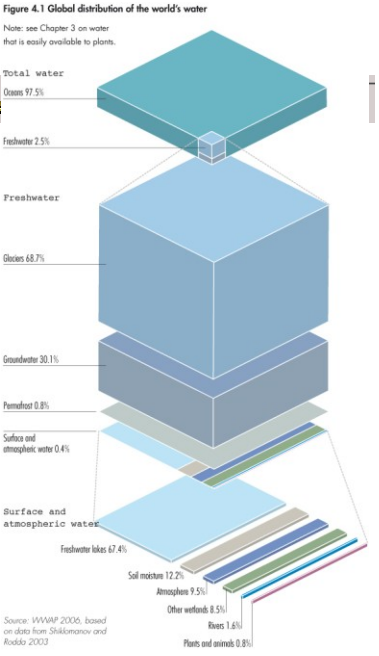
Lens showing ball movement on individual points

Game results



Treemap?

Very nice infographic

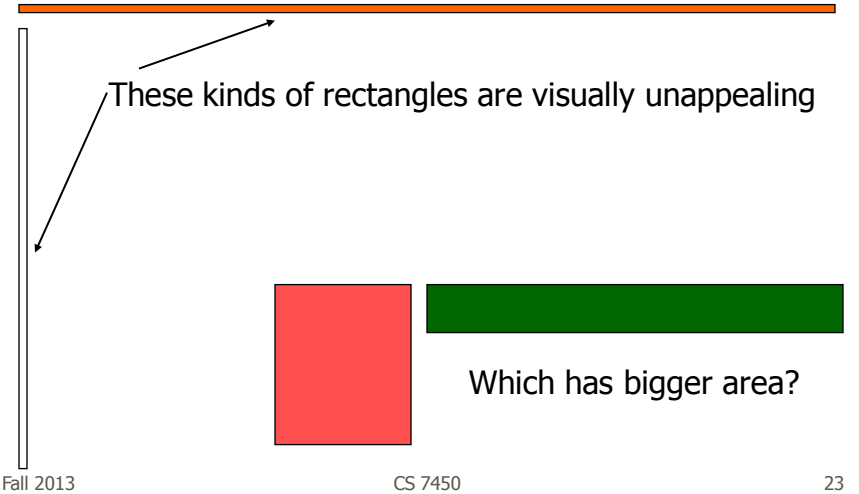


http://blog.wired.com/wiredscience/2008/06/awesome-infogra.html

Treemap Affordances

- Good representation of two attributes beyond node-link: 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
  - Borders help on smaller trees, but take up too much area on large, deep ones

Aspect ratios



Variation

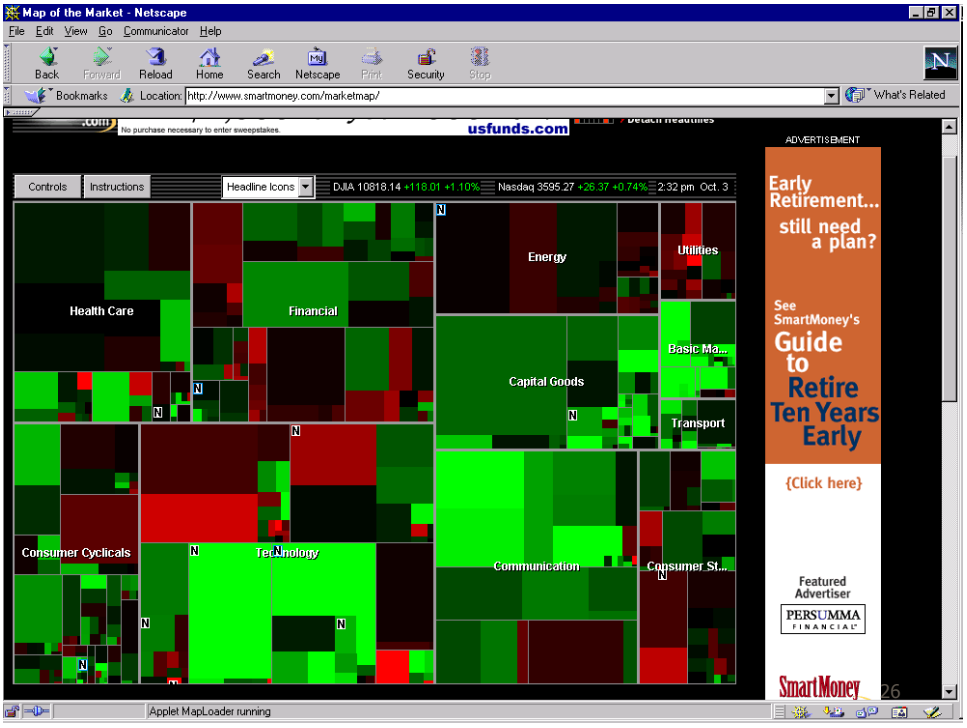
- Can rectangles be made more square? ……think about it……
- In general, a very hard problem!

Variation: "Cluster" Treemap

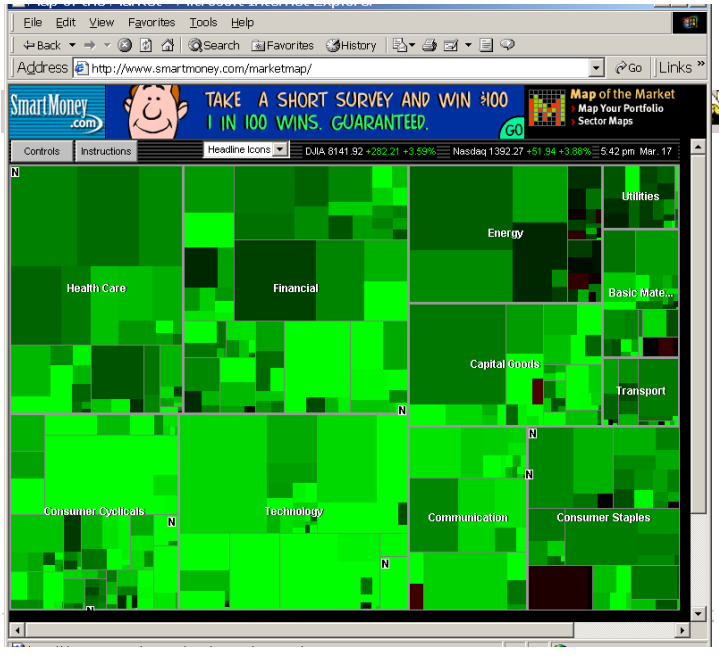
- SmartMoney.com Map of the Market
  - Illustrates stock movements
  - "Compromises" treemap algorithm to avoid bad aspect ratios
  - Basic algorithm (divide and conquer) with some hand tweaking
  - Takes advantage of shallow hierarchy
  - `www.smartmoney.com/marketmap`

Image on next slide

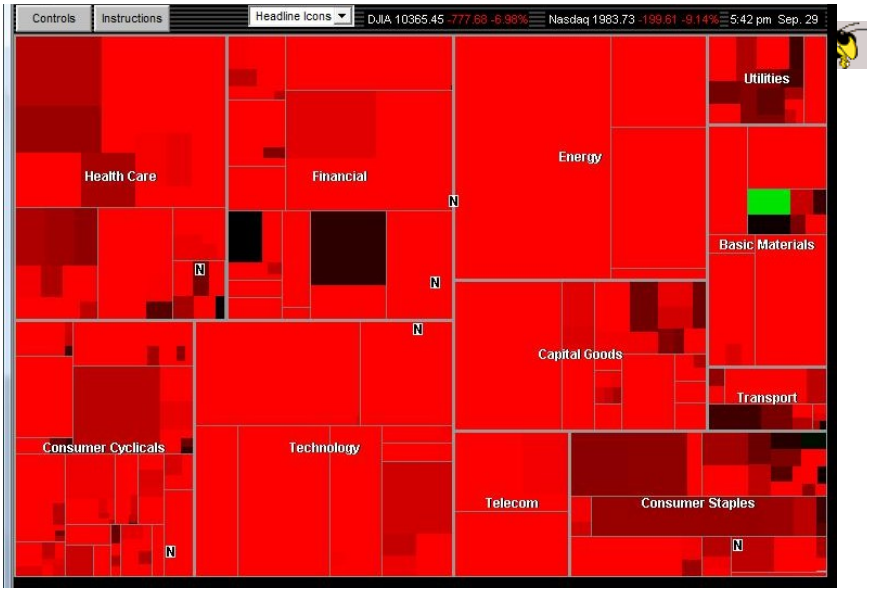
Wattenberg
CHI '99



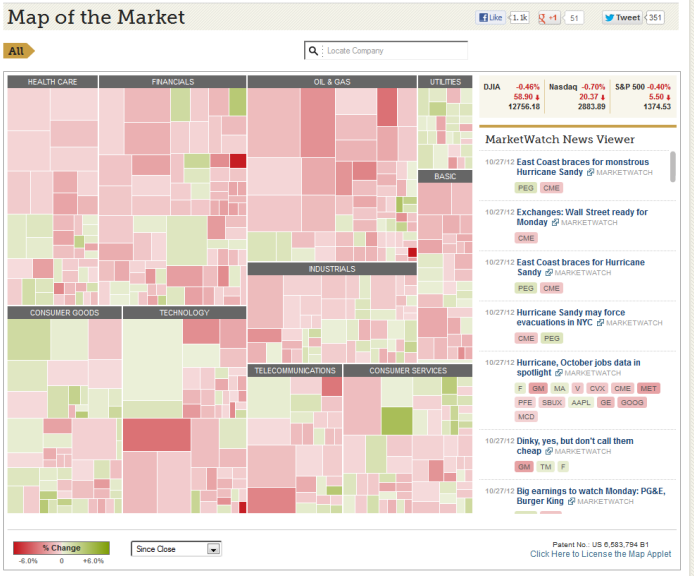
A good day :^)



More recent times Sept. 29, 2008



New One



I don't like it as much

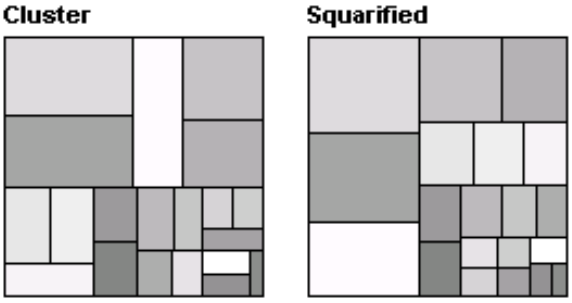
(Where's the nice control panel?)

SmartMoney Review

- Tufte-esque micro/macro view
- Dynamic user interface operations add to impact
- One of best applications of an InfoVis techniques that I've seen

Other Treemap Variations

- Squarified treemap
  - Bruls, Huizing, van Wijk, EuroGraphics '00
  - Alternate approach, similar results



Square Algorithm Problems

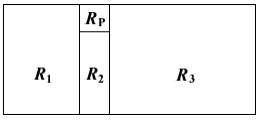
- Small changes in data values can cause dramatic changes in layout
- Order of items in a group may be important

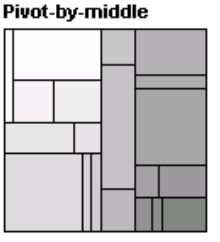
New Square Algorithms

- Pivot-by-size and pivot-by-middle

Partition area into 4 regions
Pick pivot element Rp
  Size: Largest element
  Middle: Middle element
R_1 - elements earlier in list than pivot
R_2 - elements in list before R_3 and also that makes Rp have aspect ratio closest to 1

Shneiderman & Wattenberg
InfoVis '01





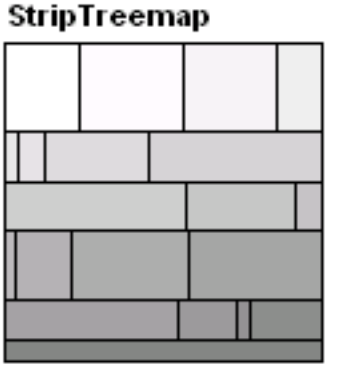
New Variation

- Strip treemap

Use strips to place items

Put new rectangle into strip
If it makes average aspect ratio of all rectangles in strip go down, keep it there
If it makes aspect ratio go up, put it back and move to next strip

Bederson, Shneiderman & Wattenberg
ACM Trans on Graphics '02

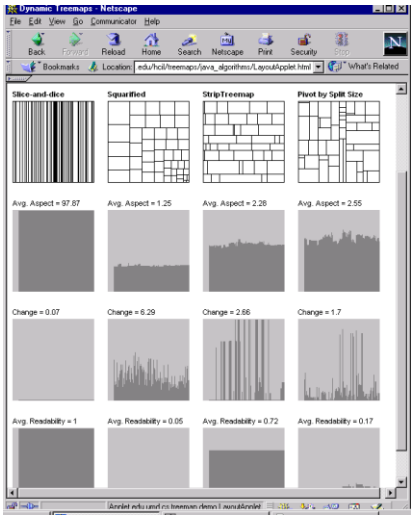


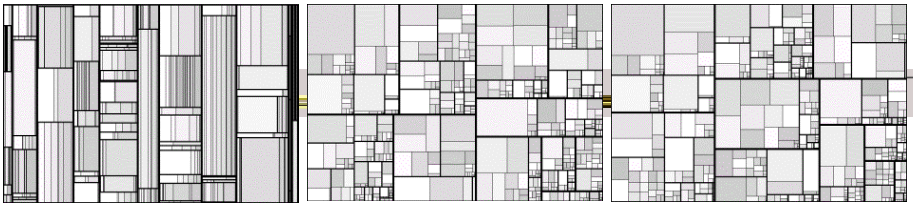
www.cs.umd.edu/hcil/treemap-history/java_algorithms/LayoutApplet.html

Compare results

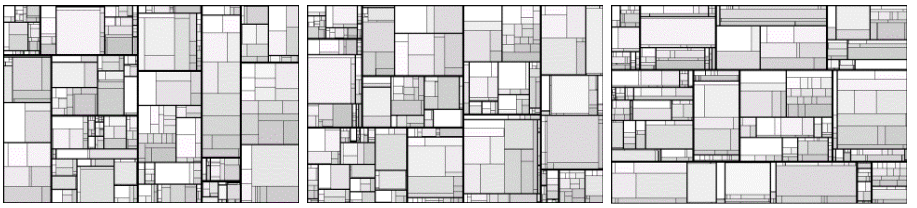
Compare
- slice and dice
- squarified
- strip
- pivot

techniques by
- aspect ratio
  - width to height
- structural change
  - metric designed to measure movements of items
- readability
  - metric based on changes in direction of eye gaze as items scanned





Slice-and-dice Cluster Squarified



Pivot-by-middle Pivot-by-size Strip

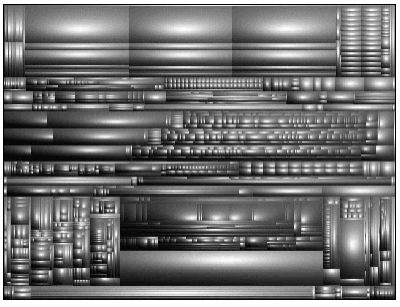
Showing Structure

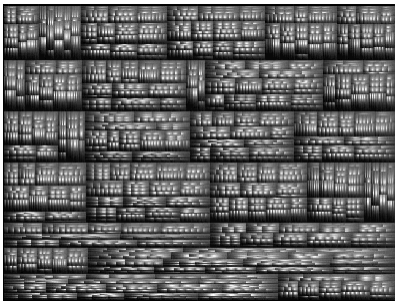
- Regular borderless treemap makes it challenging to discern structure of hierarchy, particularly large ones
  - Supplement Treemap view
  - Change rectangles to other forms

Variation: Cushion Treemap

Add shading and texture to help convey structure of hierarchy

Van Wijk & van de Wetering
InfoVis '99

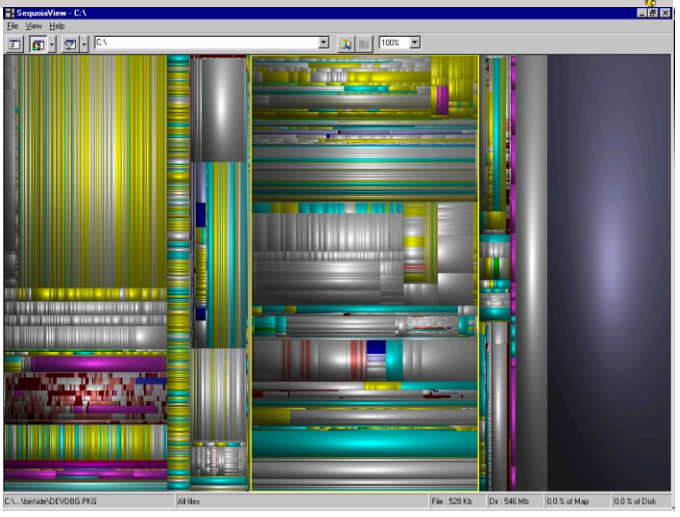




SequoiaView

www.win.tue.nl/sequoiaview/

File visualizer built using cushion treemap notion

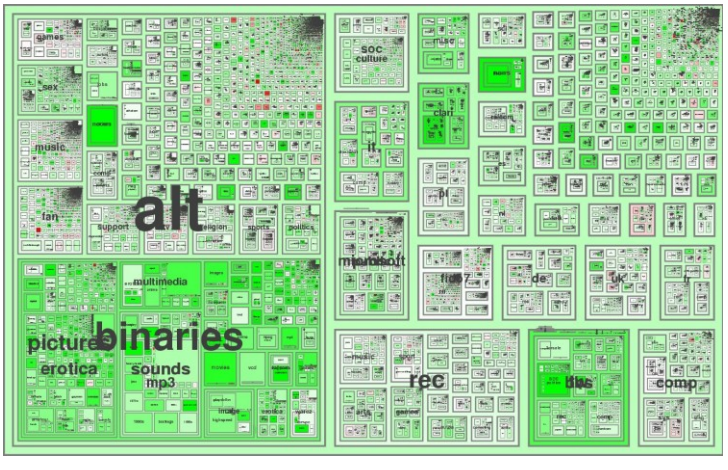


Demo

Internet News Groups

NetScan

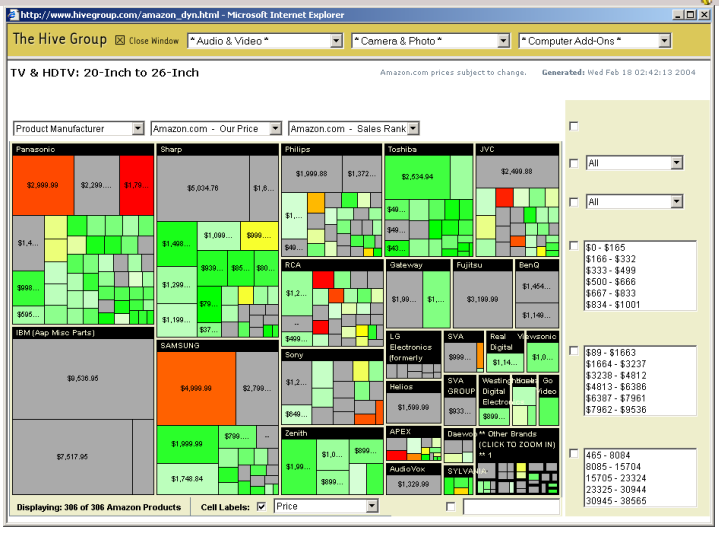
Fiore & Smith
Microsoft



Product Sales

www.hivegroup.com/amazon.html

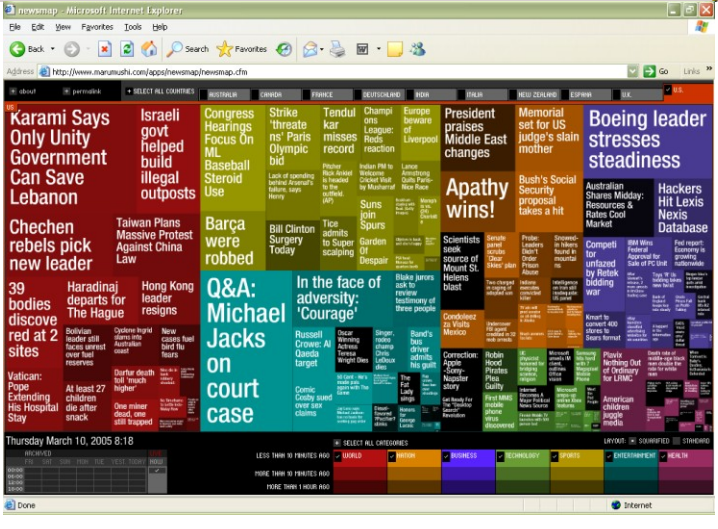
The Hive Group



News Stories

www.marumushi.com/apps/newsmap/newsmap.cfm

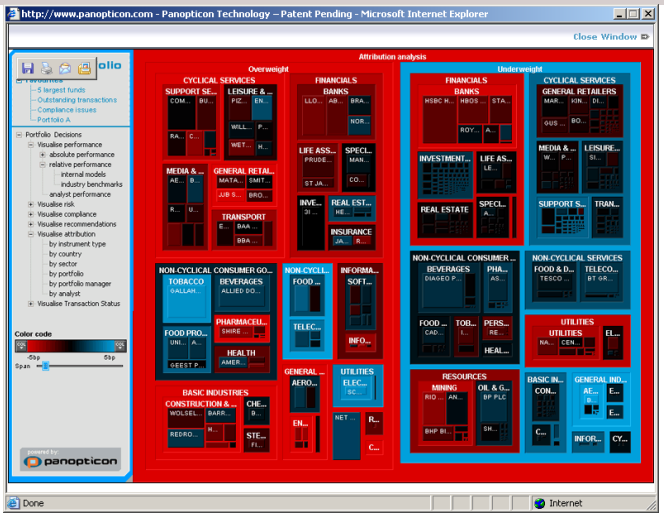
Marumushi



www.panopticon.com

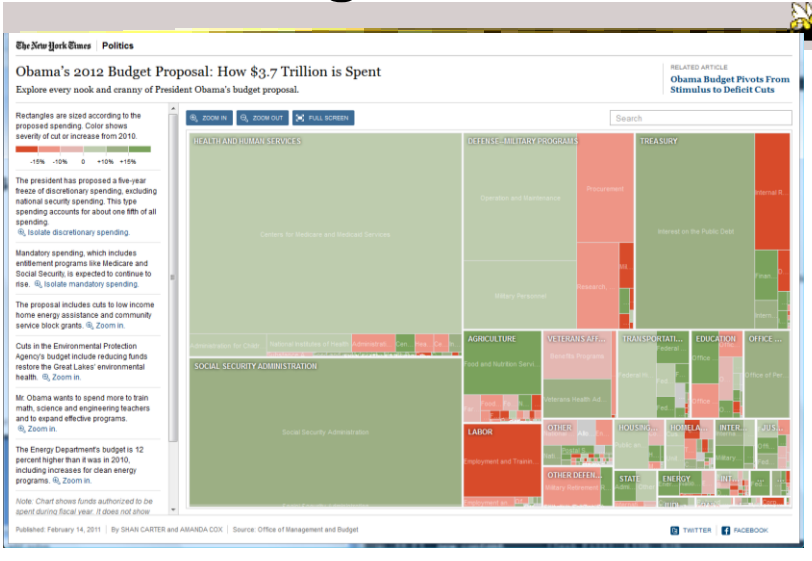
Investment Portfolios

Panopticon

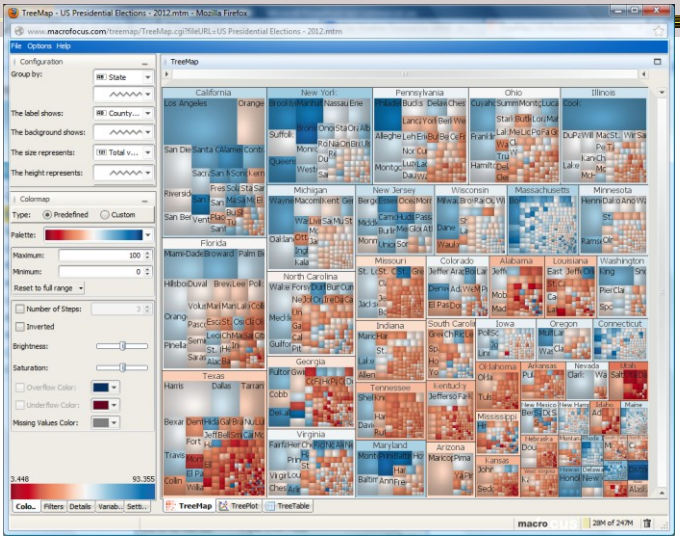


www.nytimes.com/packages/html/newsgraphics/2011/0119-budget/

Federal Budget



2012 Presidential Election



http://www.treemap.com/datasets/uselections/?goback=.gde_80552_member_184123140

Scaling Up

Fig. 5. *Hierarchical Network Map* displaying all 19,731 autonomous systems (one can still zoom in twice for details) on a large display wall (5.20m × 2.15m, 8.9 Megapixels, powered by eight projectors). The query interface on the top left shows the traffic distribution over time and specifies the selected data, in this case the traffic entering the gateway of the University of Konstanz on *well-known ports (0-1023)* on 29 November 2005 using "transferred bytes" as measure with logarithmic color mapping. One recognizes a heavy traffic load from AS 3320 (red) of "Deutsche Telekom" as well as to neighboring autonomous systems in Germany. A port histogram reveals high activity on the Web ports 80 and 443. For security and privacy reasons, the data was aggregated and sanitized.

Mansmann & Vinnik
TVCG '06

Another Problem

- What if nodes with zero value (mapped to area) are very important?
  - Example: Stock or mutual fund portfolios: Funds you don't currently hold have zero value in your portfolio, but you want to see them to potentially buy them

FundExplorer

- Show mutual fund portfolios, including funds not currently held
  - Area maps to your relative investment in fund
- Want to help the user with portfolio diversification as well
  - If I add fund X, how does that overlap with my current fund holdings?

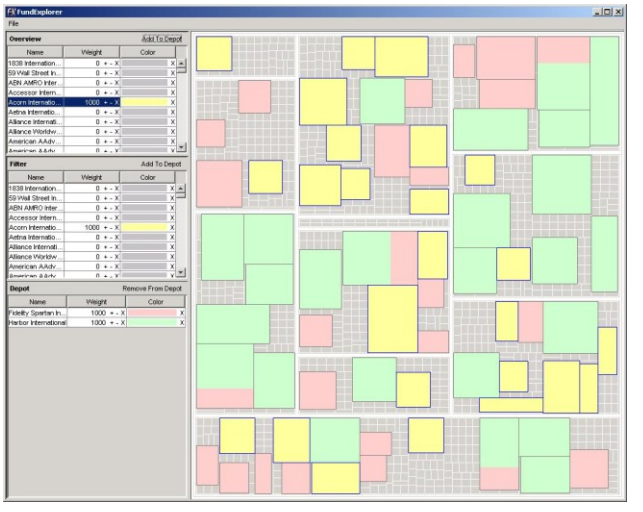
Solution

- Context Treemap – Treemap with small distortion
  - Give zero-valued items (all together) some constant proportion of screen area
  - Provide dynamic query capabilities to enhance exploration leading to portfolio diversification

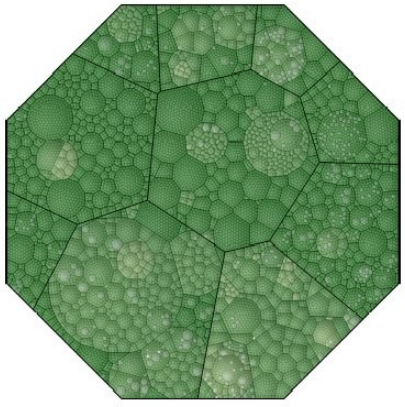
FundExplorer

Video
InfoVis '03

Demo



Voronoi Treemaps



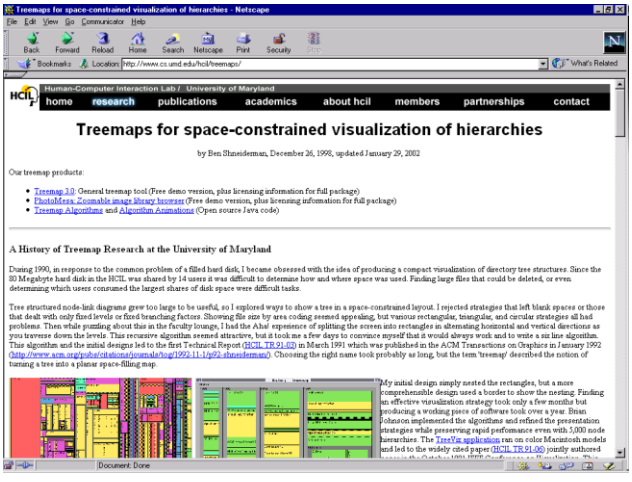
Balzer & Deussen
InfoVis '05

www.cs.umd.edu/hcil/treemap-history/

The World of Treemaps

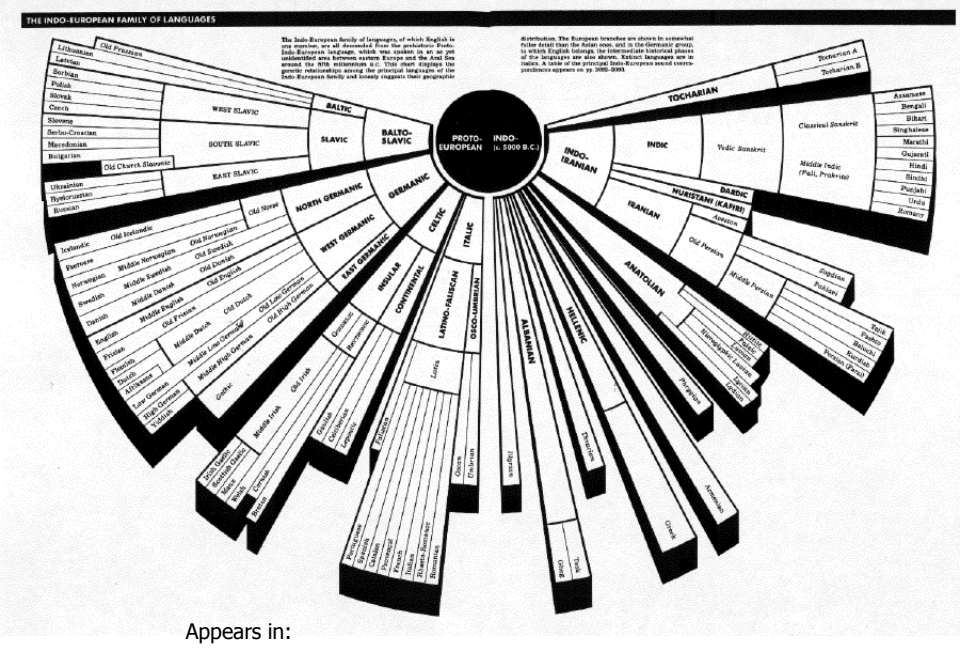
Maryland HCIL website devoted to Treemaps

Workshop in 2001 there on topic



Another Technique

- What if we used a radial rather than a rectangular space-filling technique?
  - We saw node-link trees with root in center and growing outward already...
- Make pie-tree with root in center and children growing outward
  - Radial angle now corresponds to a variables rather than area

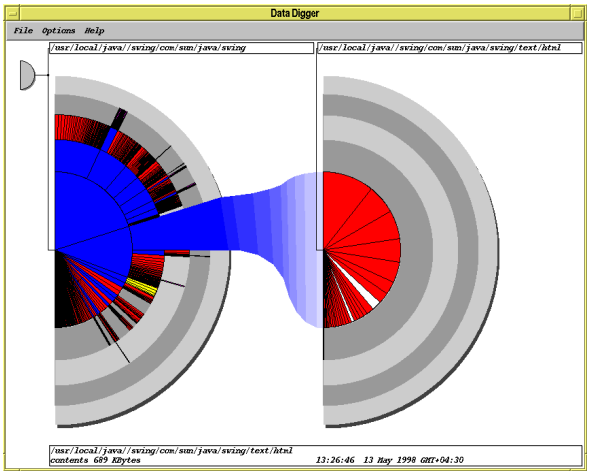


Appears in:
American Heritage Dictionary, 3rd Ed. Houghton Mifflin, 1992

Radial Space-Filling

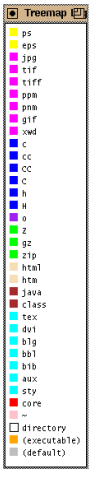
Chuah
InfoVis '98

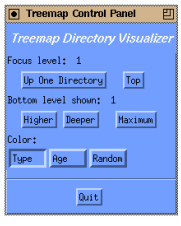
Andrews &
Heidegger
InfoVis '98



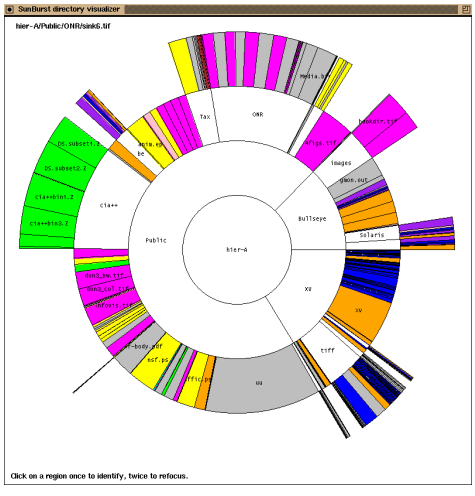
SunBurst

Stasko, Catrambone, Guzdial & McDonald
IJHCS '00





Demo

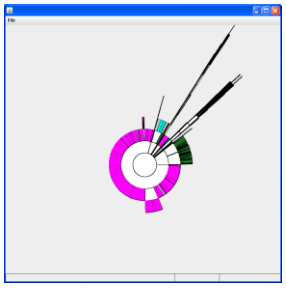


SunBurst

- Root directory at center, each successive level drawn farther out from center
- Sweep angle of item corresponds to size
- Color maps to file type or age
- Interactive controls for moving deeper in hierarchy, changing the root, etc.
- Double-click on directory makes it new root

SunBurst

- Demonstration of system



Java version built by Neel Parekh

Stasko, Catrambone, Guzdial & McDonald
IJHCS '00

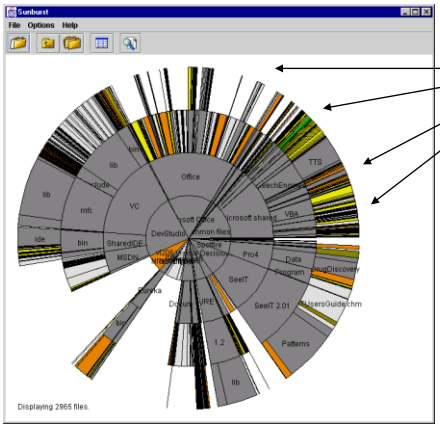
Empirical Study

- Compared SunBurst to Treemap (borderless) on a variety of file browsing tasks
  - SunBurst performed as well (or better) in task accuracy and time
  - Learning effect - Performance improved with Treemap on second session
  - Strong subjective preference (51-9) for SunBurst
  - Participants cited more explicit depiction of structure as an important reason

More to come on evaluation...

SunBurst Negative

- In large hierarchies, files at the periphery are usually tiny and very difficult to distinguish



examples

Fix: Objectives

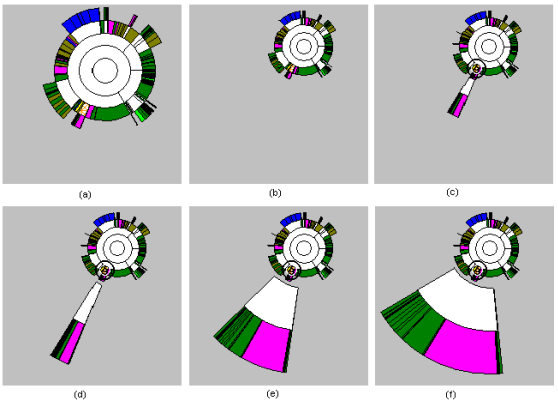
- Make small slices bigger
- Maintain full circular space-filling idea
- Allow detailed examination of small files within context of entire hierarchy
- Don't alter ratios of sizes
- Avoid use of multiple windows or lots of scrollbars
- Provide an aesthetically pleasing interface in which it is easy to track changes in focus

3 Solutions

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

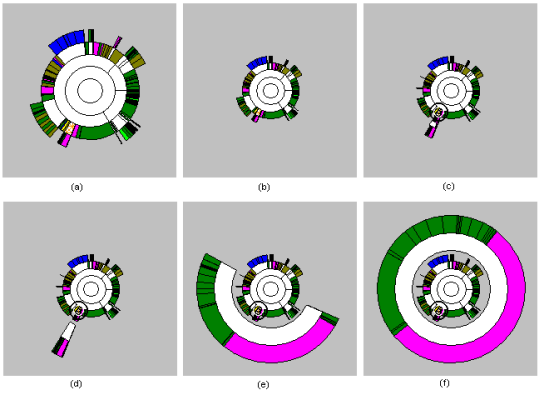
Stasko & Zhang
InfoVis '00

Angular Detail



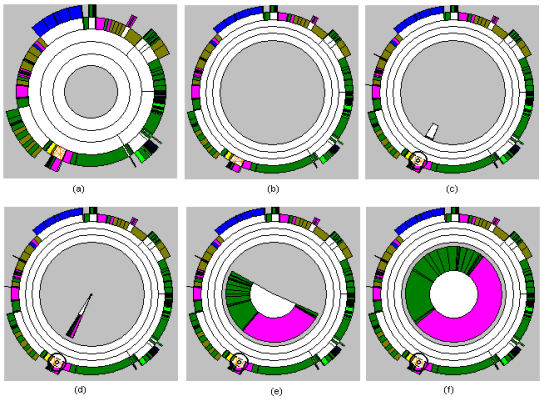
- Most "natural"
- Least space-efficient
- Most configurable by user

Detail Outside



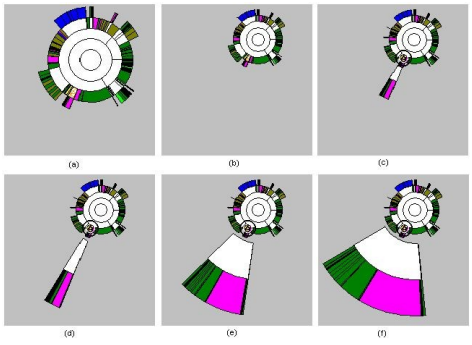
- Exhibits non-distorted miniature of overview
- Somewhat visually disconcerting
- Focus is quite enlarged (large circumference and 360°)
- Relatively space efficient

Detail Inside



- Perhaps least intuitive and most distorting
- Items in overview are more distinct (larger circumference)
- Interior 360° for focus is often sufficient

See in Action



Video

Stasko & Zhang
InfoVis '00

Key Components

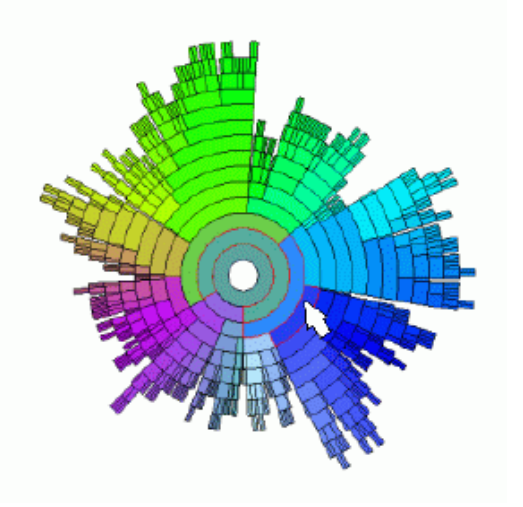
- Two ways to increase area for focus region: larger sweep angle and longer circumference
- Smooth transitions between overview and focus allow viewer to track changes
- Always display overview
- Allow focus selections from anywhere: normal display, focus or overview regions

Potential Follow-on Work

- Multiple foci
- Varying radii for different levels in hierarchy
- Use quick-keys to walk through neighboring files
- Smarter update when choosing new focus region from existing focus
- Fourth method: expand angle of focus in place by compressing all others

InterRing

Provides many of those follow-on capabilities and new operations

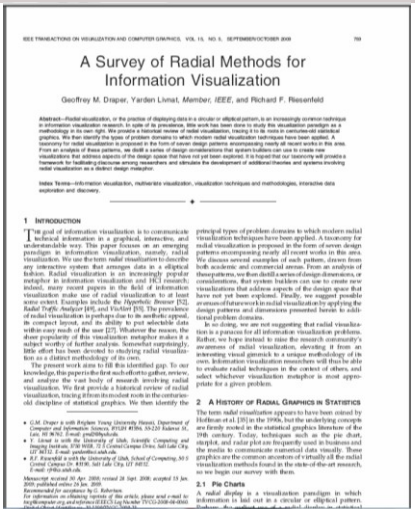


Yang, Ward & Rudensteiner
InfoVis `02

Even Sand Crabs Do It

http://www.flickr.com/photos/jkr1812/2234846316/in/gallery-49563472@N07-72157624817856060/lightbox/

Survey of Radial Techniques



A Survey of Radial Methods for Information Visualization

Geoffrey M. Draper, Yarden Livnat, *Member, IEEE*, and Richard F. Riesenfeld

Draper et al
TVCG `09

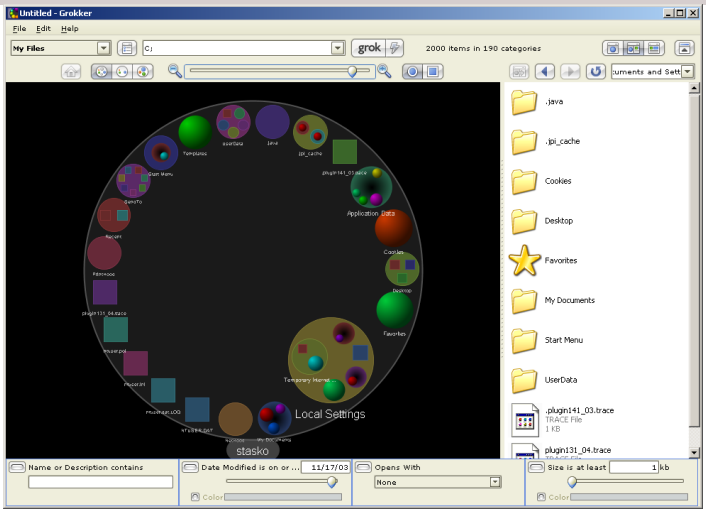
More Alternatives

- Combine space-filling hierarchy presentations (really nesting) with zooming
- Children drawn inside of parent, but not totally encompassing

Grokker

www.groxis.com

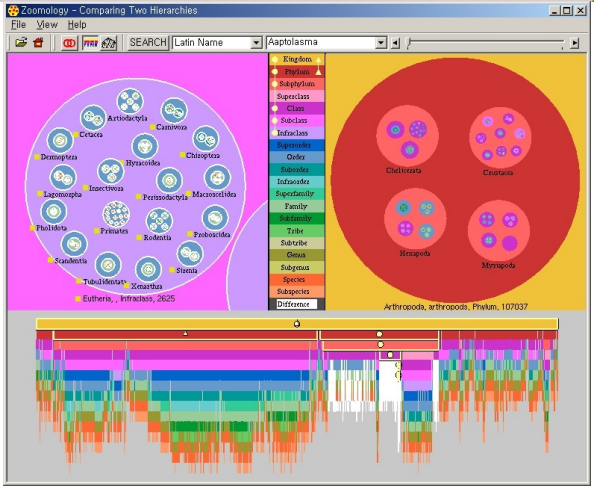
Demo



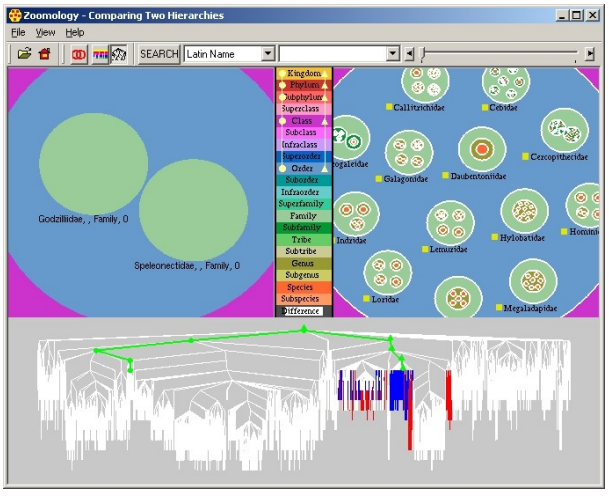
Zoomology

CS 7450
Spring '03
project

InfoVis '03
Contest Winner
Best Student
entry



Alternate View



Video

Circle Packing

Wang, Wang, Dai & Wang
CHI '06

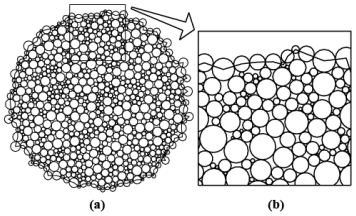


Figure 4. Packing 1000 circles with random radii

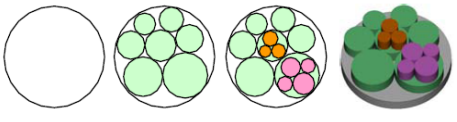
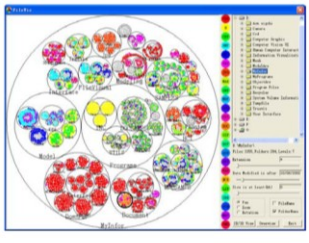
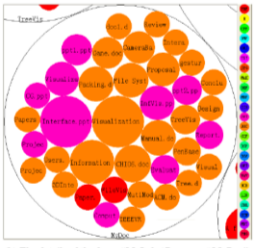


Figure 5. Pack circles into a circle recursively



(a) User interface and the overview of "D:\MyInfor"



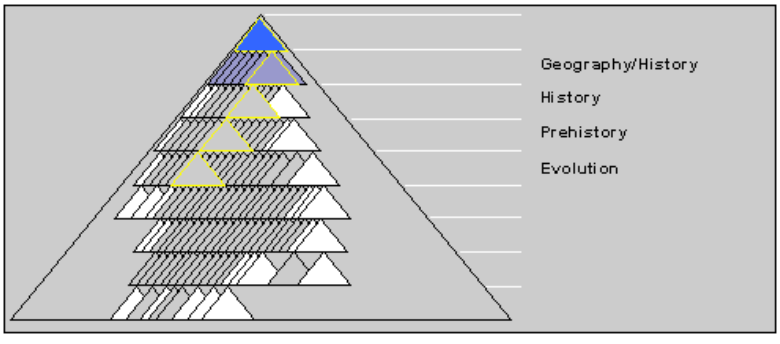
(b) The details of the focus "MyInfor\Document\MyDoc"

(c) 3D nested cylinders and spheres

Hybrid Approaches

- Mix node-link and space-filling

CHEOPS



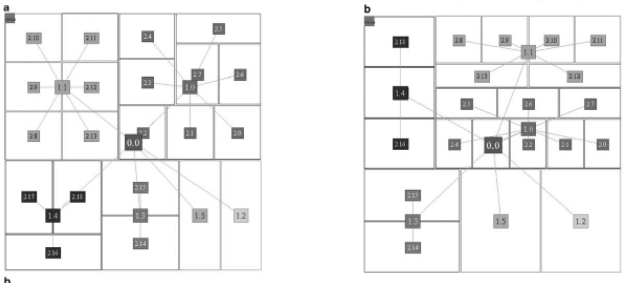
(Saw last time)

Beaudoin, Parent, Vroomen, Vis '96

EnCon

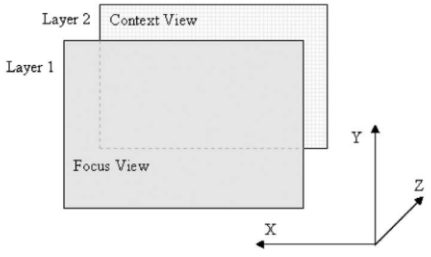
Nguyen & Huang
Information Visualization '05

- Explicit combination of node-link and treemap-like techniques
- Partition space into hierarchical regions, then draw node link into that

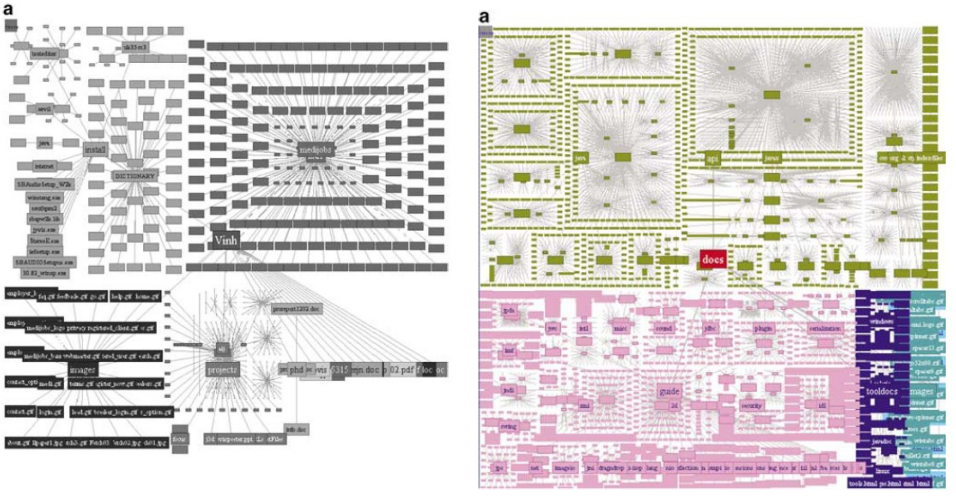


Focus + Context → Zooming + Layering

- Uses 2 Layers with semi-transparency
- Viewer can zoom and swap
- Provides animated transitions in-between



EnCon Sample Views



Summary

- Node-link diagrams or space-filling techniques?
- It depends on the properties of the data
  - Node-link typically better at exposing structure of information structure
  - Space-filling good for focusing on one or two additional variables of cases

Great Visual Summary

Downloadable poster

http://www.informatik.uni-rostock.de/~hs162/treeposter/oldposter/poster.html

Zoomed In

Version 2

http://treevis.net

Upcoming

- Interaction
  - Reading
    - Yi et al '07
- Overview and Detail
  - Reading
    - Bederson et al '04

References

- Spence and CMS texts
- All referred to papers