

Hierarchies and Trees 2 (Space-filling)



CS 7450 - Information Visualization
October 30, 2013
John Stasko

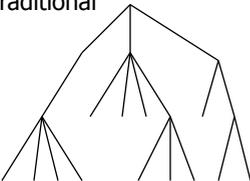
Hierarchies **Recall**



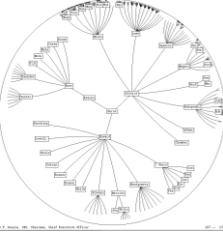
- Definition
 - Data repository in which cases are related to subcases
 - Can be thought of as imposing an ordering in which cases are parents or ancestors of other cases

Last Time: Node-Link Reps

Traditional



Hyperbolic tree



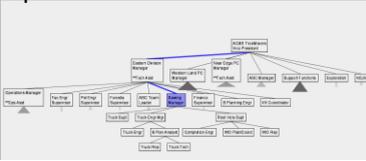
Lamping & Rao

ConeTree



Card, Mackinlay & Robertson

SpaceTree



Plaisant, Grosjean & Bederson

Fall 2013

CS 7450

3

Node-link Shortcoming

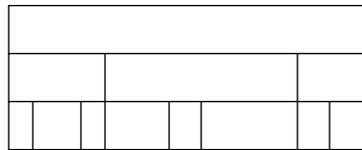
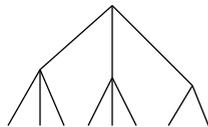
- Difficult to encode more variables of data cases (nodes)
 - Shape
 - Color
 - Size
 - ...but all quickly clash with basic node-link structure

Space-Filling Representation



Each item occupies an area

Children are "contained" under parent



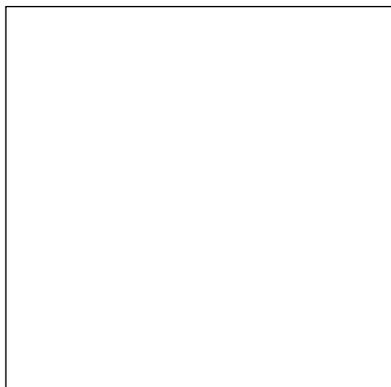
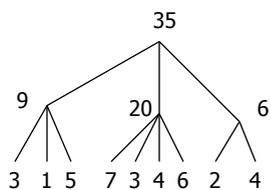
One example: "Icicle plot"

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

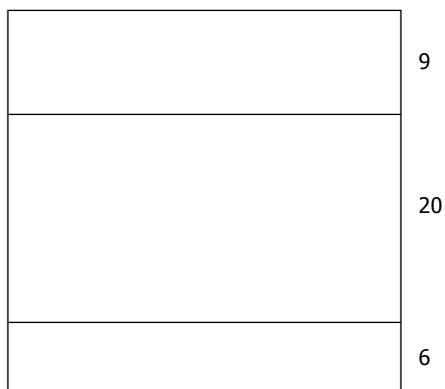
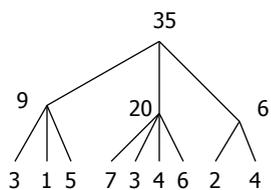


Fall 2013

CS 7450

7

Example

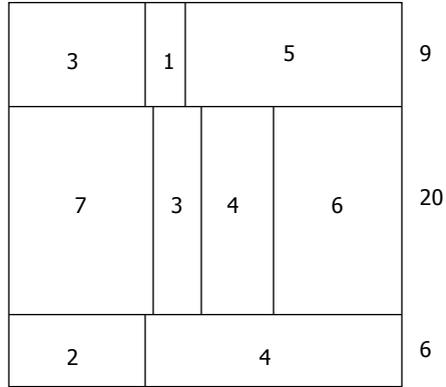
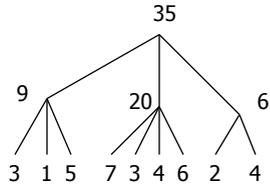


Fall 2013

CS 7450

8

Example



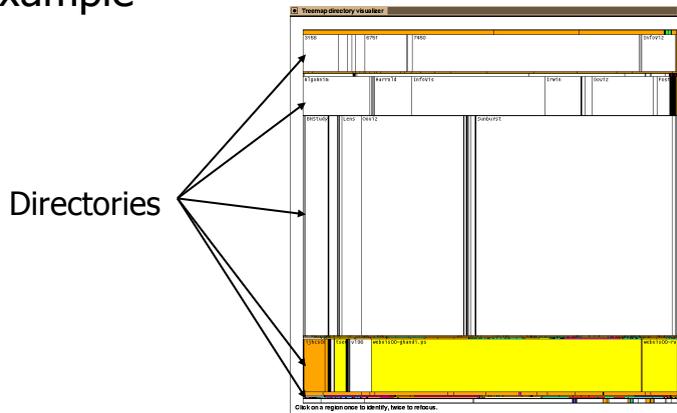
Fall 2013

CS 7450

9

Treemap

- Example

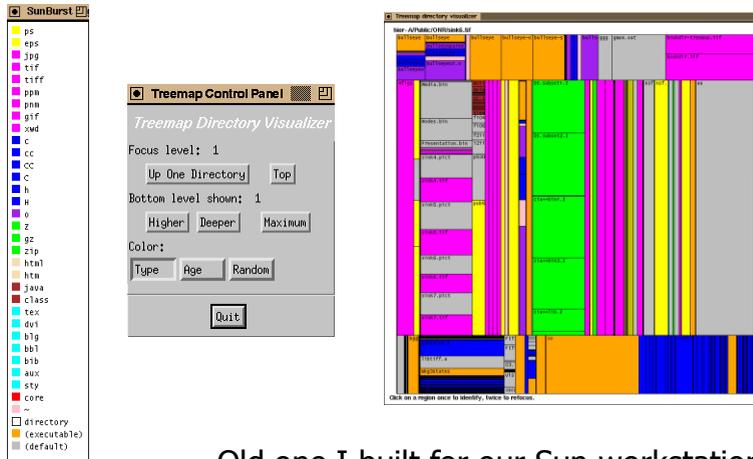


Fall 2013

CS 7450

10

Treemap Example

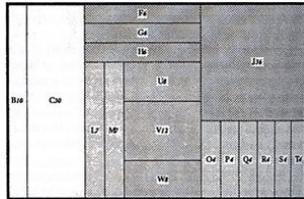


Old one I built for our Sun workstations

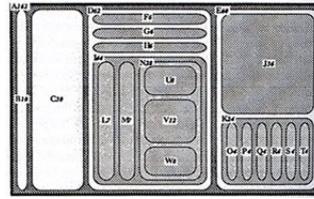
Treemap Algorithm

```
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  
}
```

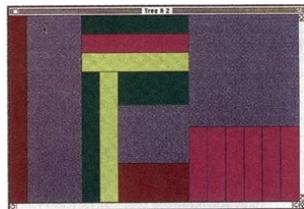
Nested vs. Non-nested



Non-nested Tree-Map



Nested Tree-Map



Fall 2013

CS 7450

13

Applications

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

Fall 2013

CS 7450

14

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

Fall 2013

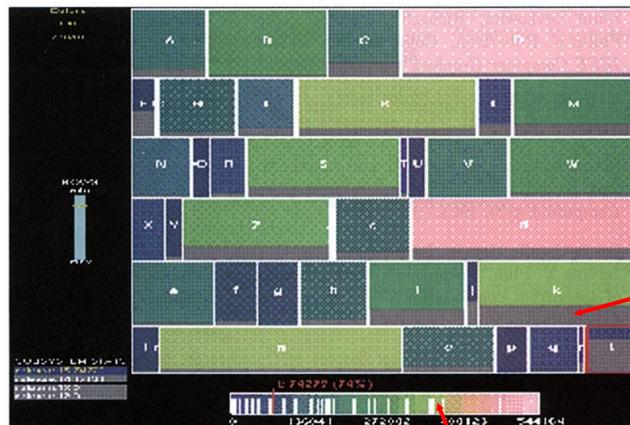
CS 7450

15

Sample View 1



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



New code
in this release

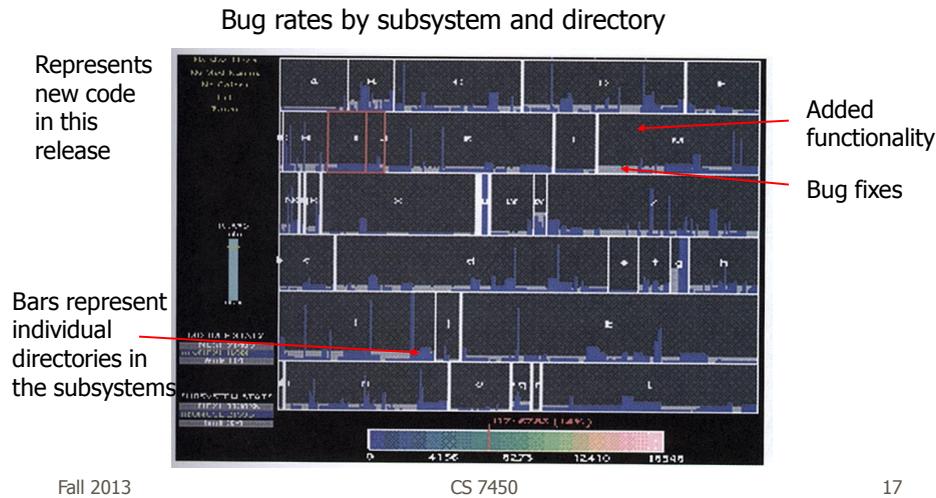
Fall 2013

CS 7450

Size

16

Sample View 2



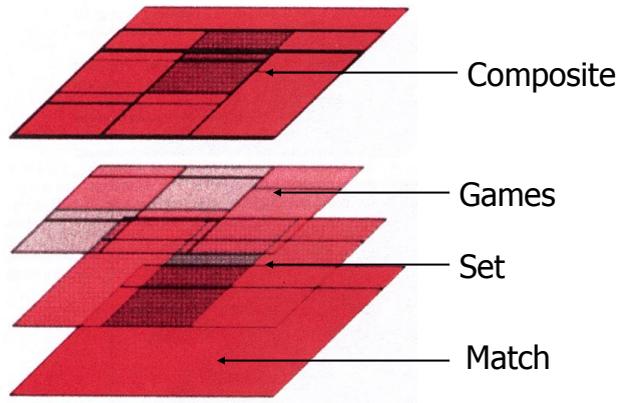
Tennis Viewing Application



- 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



Fall 2013

CS 7450

19

Simulated Match Results



Match view

Bond won

Set results

Lens showing ball movement on individual points

Game results



Fall 2013

CS 7450

20

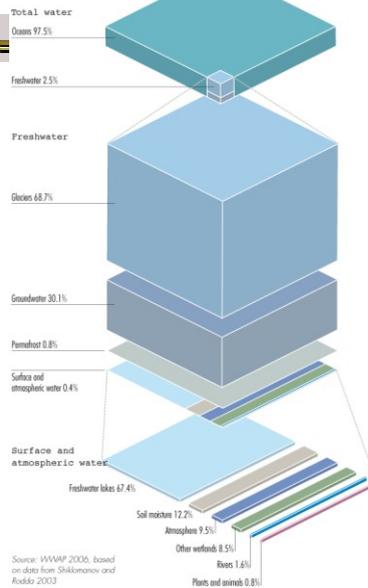
Treemap?



Very nice infographic

Figure 4.1 Global distribution of the world's water

Note: see Chapter 3 on water that is easily available to plants.



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

Source: WWAP 2006, based on data from Gleason and Rodda 2003

Fall 2013

CS 7450

21

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

Fall 2013

CS 7450

22

Aspect ratios



These kinds of rectangles are visually unappealing

Which has bigger area?

Fall 2013 CS 7450 23

Variation

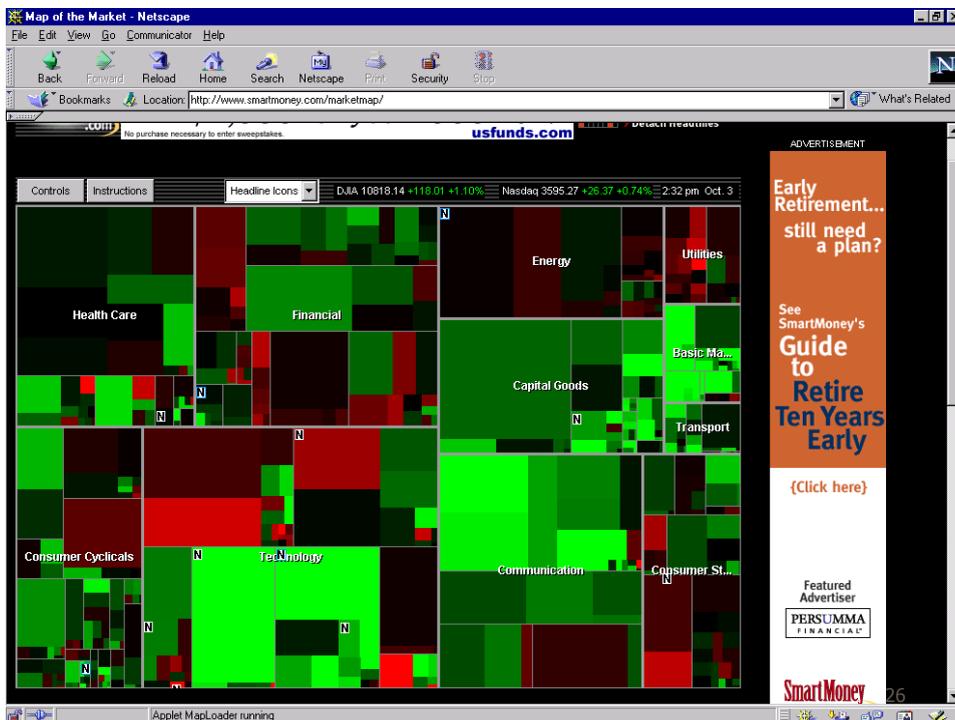


- Can rectangles be made more square?
.....think about it.....
- In general, a very hard problem!

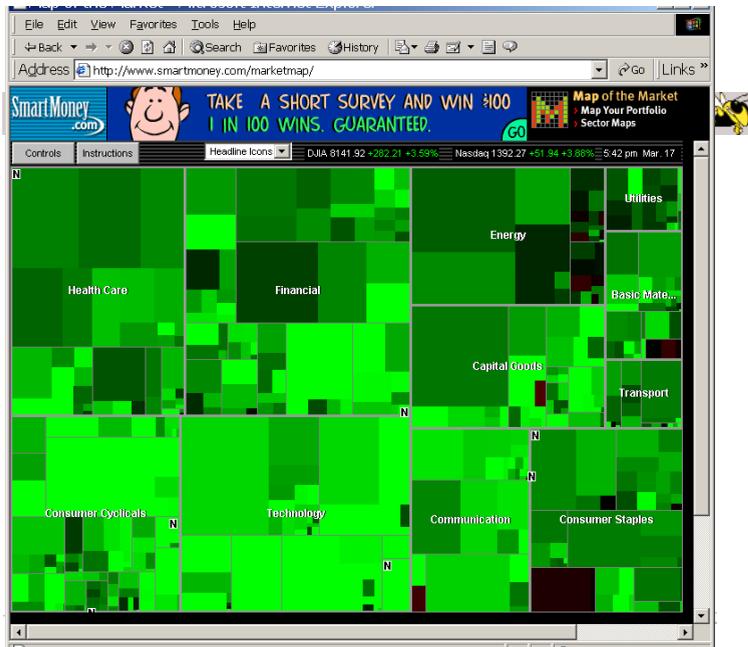
Variation: “Cluster” Treemap

- 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`

Fall 2013 Image on next slide CS 7450 Wattenberg CHI '99 25



A good day :^)



Fall 2013

CS 7450

27

More recent times

Sept. 29, 2008

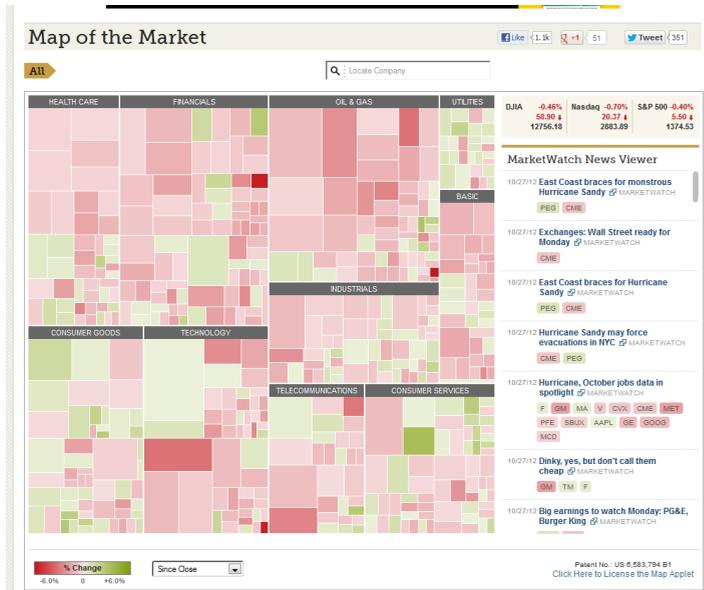


Fall 2013

CS 7450

28

New One



I don't like it as much

(Where's the nice control panel?)

Fall 2013

CS 7450

29

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

Fall 2013

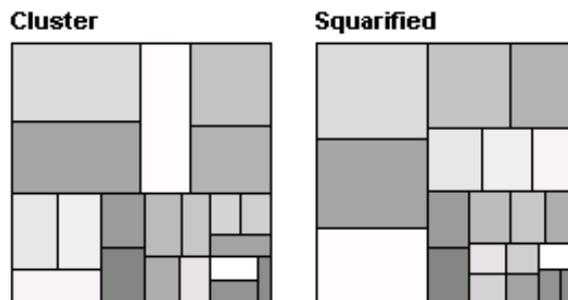
CS 7450

30

Other Treemap Variations



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



Fall 2013

CS 7450

31

Square Algorithm Problems



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

Fall 2013

CS 7450

32

New Square Algorithms



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

Partition area into 4 regions

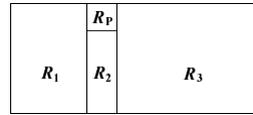
Pick pivot element R_p

Size: Largest element

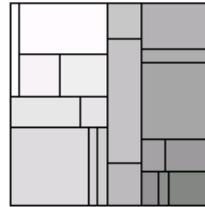
Middle: Middle element

R_1 - elements earlier in list than pivot

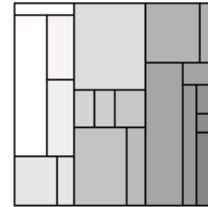
R_2 - elements in list before R_3 and also that makes R_p have aspect ratio closest to 1



Pivot-by-middle



Pivot-by-size



Shneiderman & Wattenberg
InfoVis '01

Fall 2013

CS 7450

33

New Variation



- Strip treemap

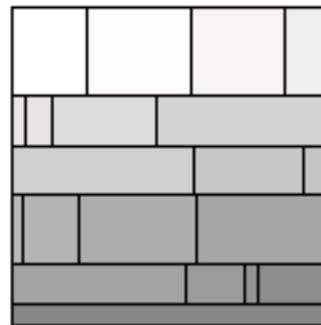
Use strips to place items

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

StripTreemap



Bederson, Shneiderman & Wattenberg
ACM Trans on Graphics '02

Fall 2013

CS 7450

34

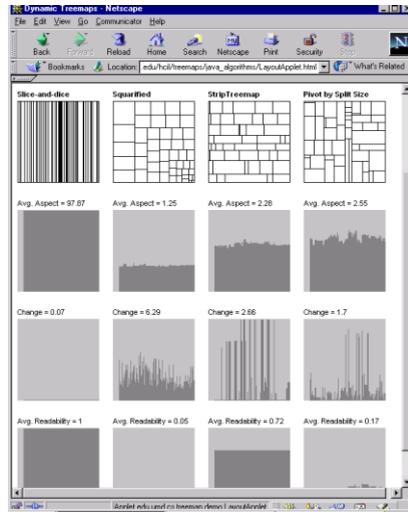
Compare results

Compare

- slice and dice
- squarified
- strip
- pivot

techniques by

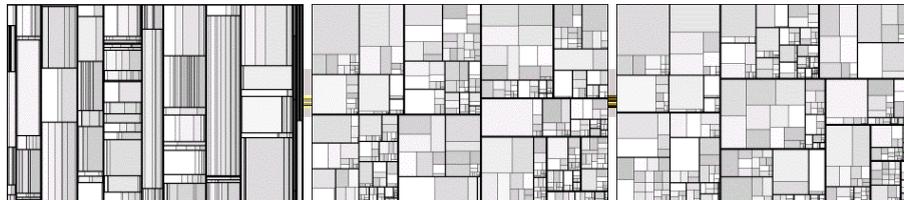
- aspect ratio
width to height
- structural change
metric designed to measure movements of items
- readability
metric based on changes in direction of eye gaze as items scanned



Fall 2013

CS 7450

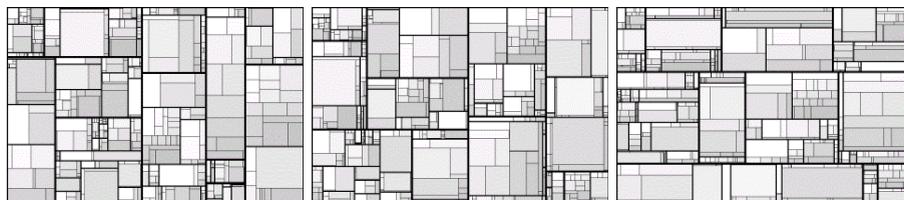
35



Slice-and-dice

Cluster

Squarified



Pivot-by-middle

Pivot-by-size

Strip

Fall 2013

CS 7450

36

Showing Structure



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

Fall 2013

CS 7450

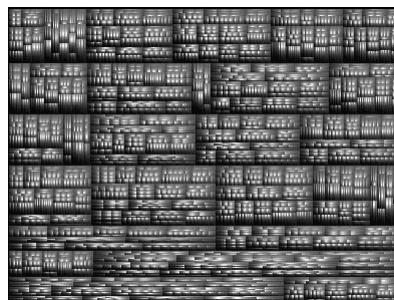
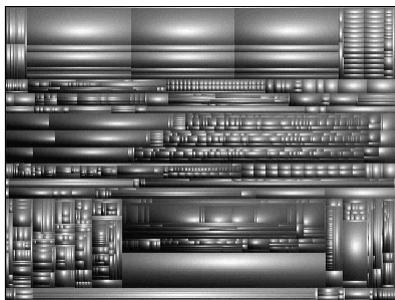
37

Variation: Cushion Treemap



Add shading and texture to help convey structure of hierarchy

Van Wijk & van de Wetering
InfoVis '99



Fall 2013

CS 7450

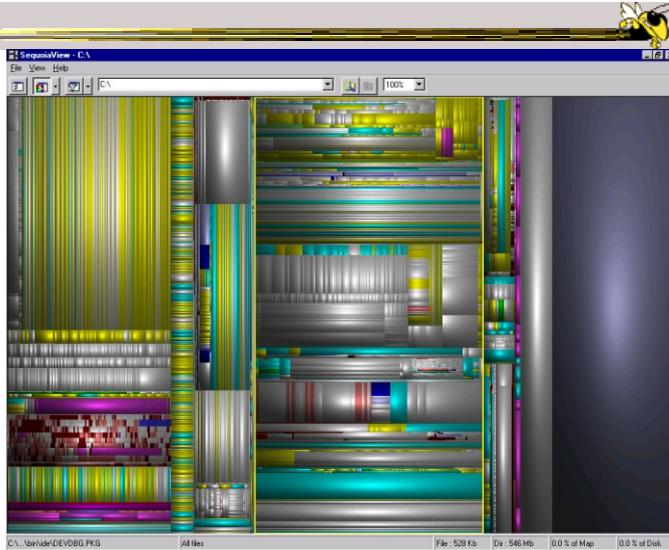
38

SequoiaView

www.win.tue.nl/sequoiaview/

File visualizer
built using
cushion treemap
notion

Demo



Fall 2013

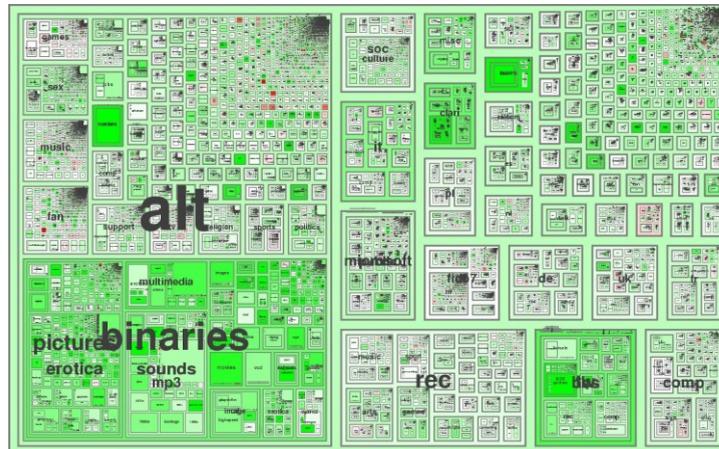
CS 7450

39

Internet News Groups

NetScan

Fiore & Smith
Microsoft



Fall 2013

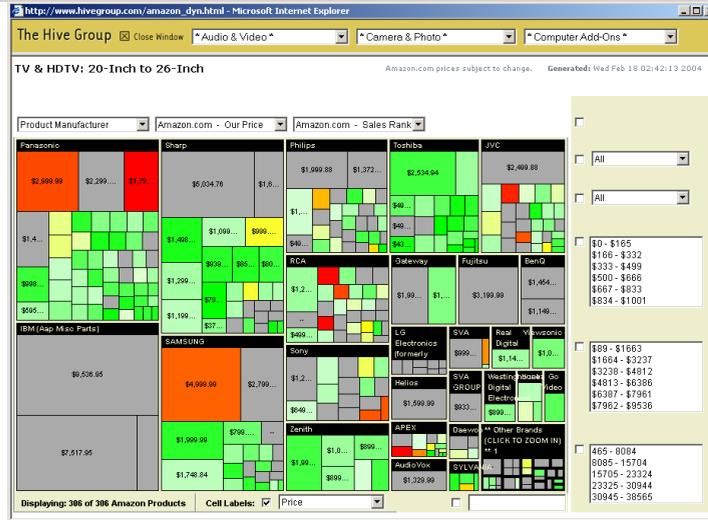
CS 7450

40

Product Sales

www.hivegroup.com/amazon.html

The Hive Group



Fall 2013

CS 7450

41

News Stories

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

Marumushi



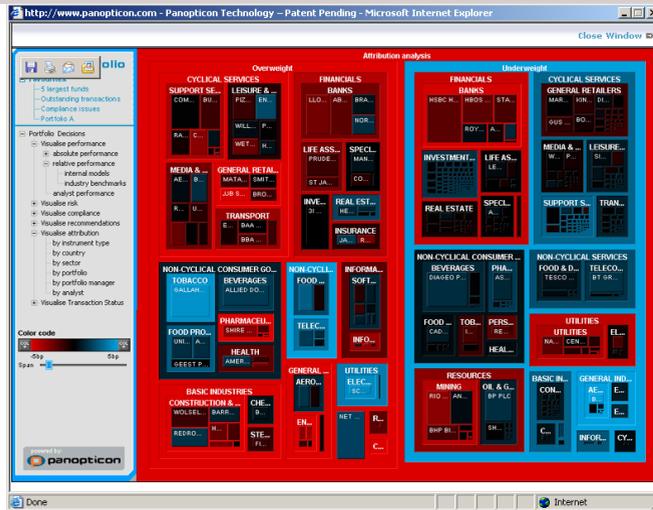
Fall 2013

CS 7450

42

Investment Portfolios

Panopticon

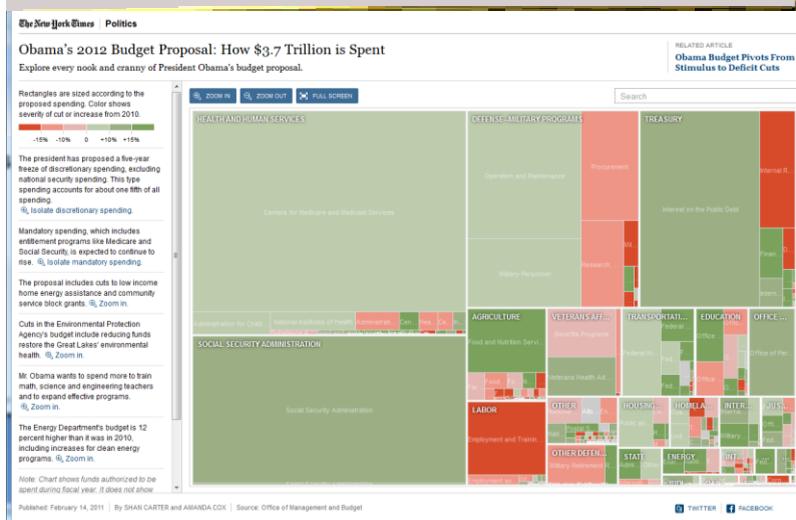


Fall 2013

CS 7450

43

Federal Budget

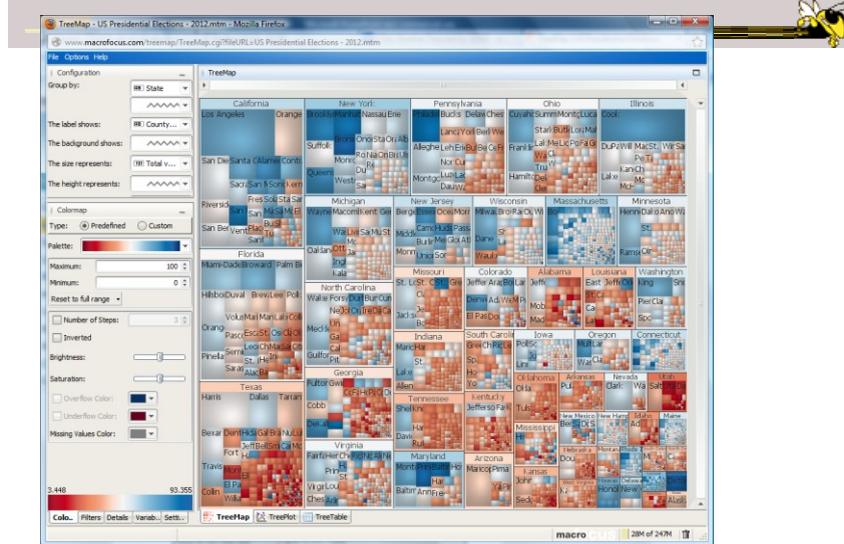


Fall 2013

CS 7450

44

2012 Presidential Election



http://www.treemap.com/datasets/uselections/?goback=.gde_80552_member_184123140
 Fall 2013 CS 7450 45

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.

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

Fall 2013

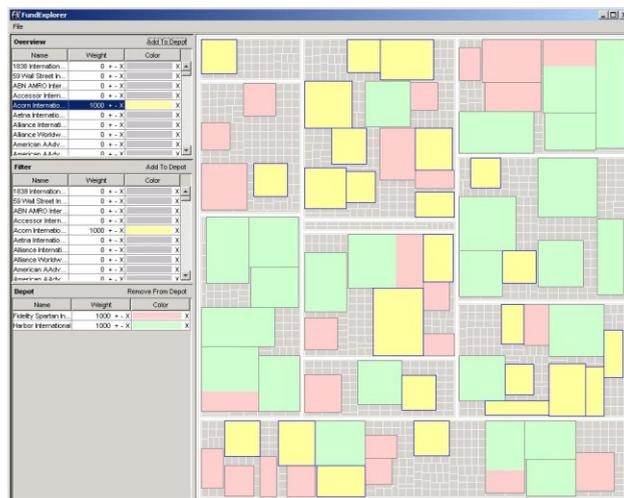
CS 7450

49

FundExplorer

Video
InfoVis '03

Demo

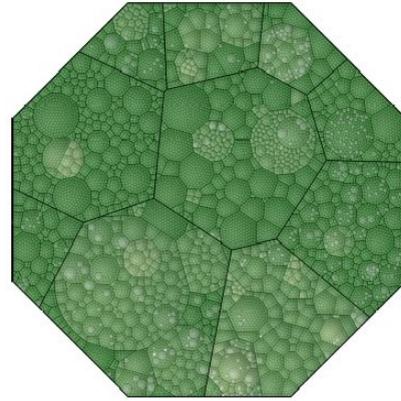
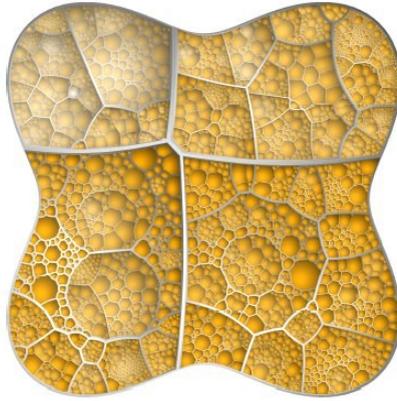


Fall 2013

CS 7450

50

Voronoi Treemaps



Balzer & Deussen
InfoVis '05

Fall 2013

CS 7450

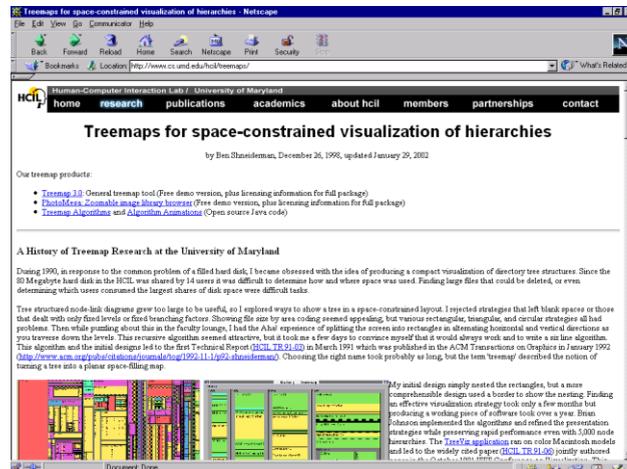
51

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

The World of Treemaps

Maryland HCIL
website devoted
to Treemaps

Workshop in
2001 there on
topic



Fall 2013

CS 7450

52

Another Technique

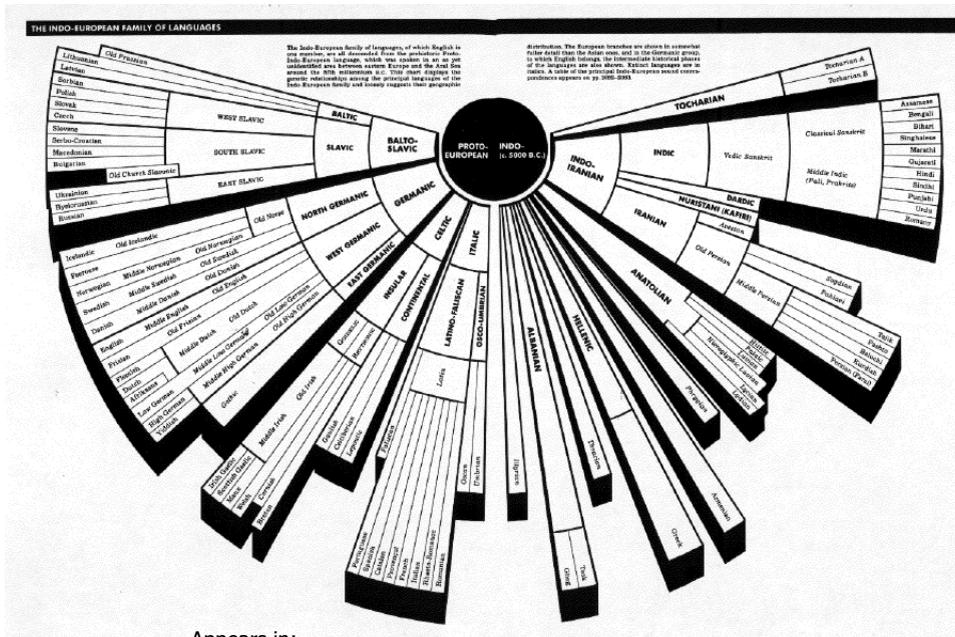


- What if we used a radial rather than a rectangular space-filling technique?
 - We saw node-link trees with root in center and growing outward already...
- Make pie-tree with root in center and children growing outward
 - Radial angle now corresponds to a variables rather than area

Fall 2013

CS 7450

53



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

Fall 2013

CS 7450

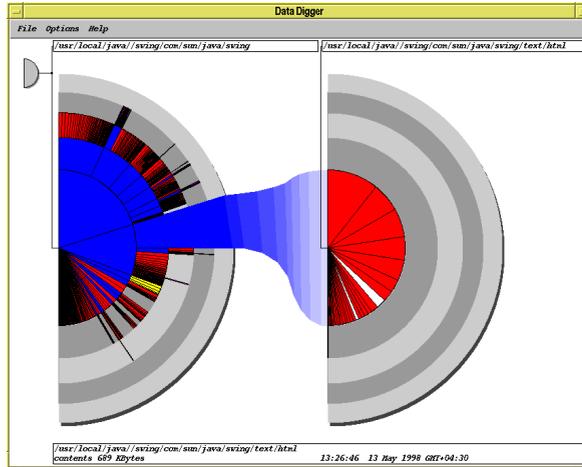
54

Radial Space-Filling



Chuah
InfoVis '98

Andrews &
Heidegger
InfoVis '98



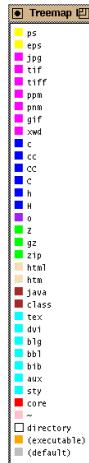
Fall 2013

CS 7450

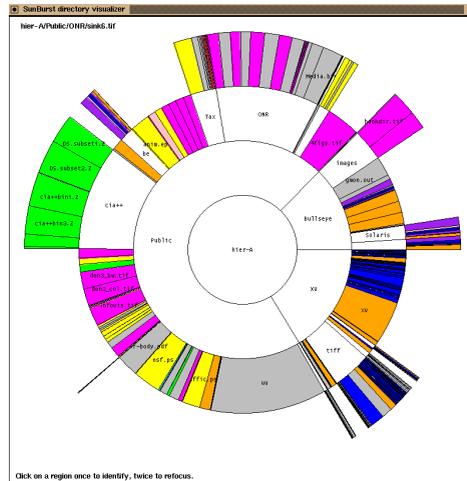
55

SunBurst

Stasko, Catrambone, Guzdial & McDonald
IJHCS '00



Demo



Fall 2013

CS 7450

56

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

Fall 2013

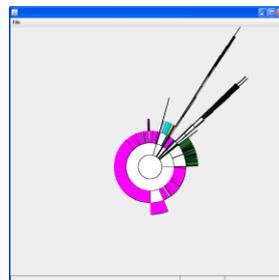
CS 7450

57

SunBurst



- Demonstration of system



Java version built by Neel Parekh

Fall 2013

CS 7450

58

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...

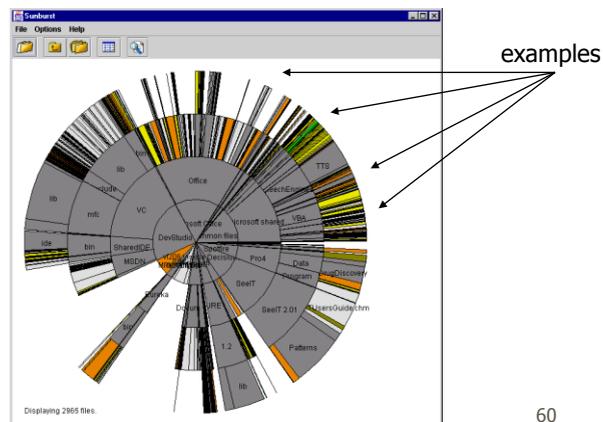
Fall 2013

CS 7450

59

SunBurst Negative

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



Fall 2013

60

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

Fall 2013

CS 7450

61

3 Solutions

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

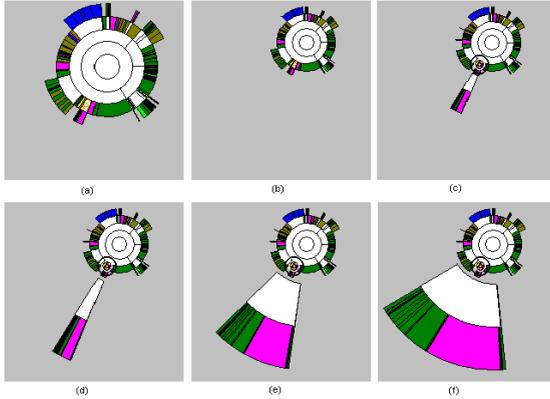
Stasko & Zhang
InfoVis '00

Fall 2013

CS 7450

62

Angular Detail



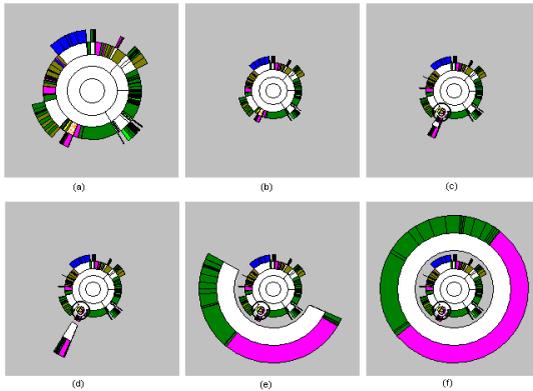
- Most “natural”
- Least space-efficient
- Most configurable by user

Fall 2013

CS 7450

63

Detail Outside



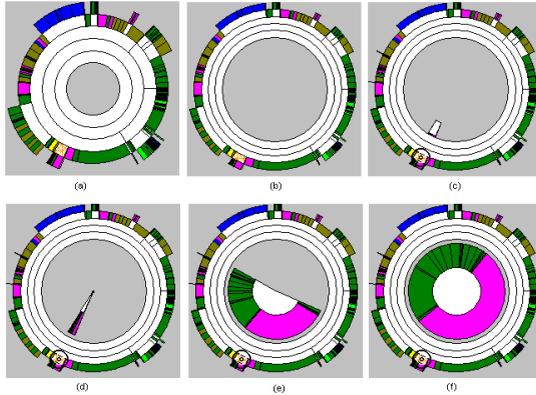
- Exhibits non-distorted miniature of overview
- Somewhat visually disconcerting
- Focus is quite enlarged (large circumference and 360°)
- Relatively space efficient

Fall 2013

CS 7450

64

Detail Inside



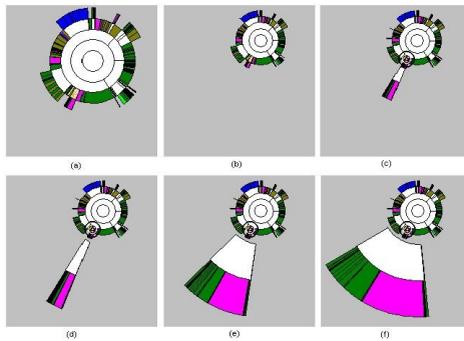
- Perhaps least intuitive and most distorting
- Items in overview are more distinct (larger circumference)
- Interior 360° for focus is often sufficient

Fall 2013

CS 7450

65

See in Action



Video

Stasko & Zhang
InfoVis '00

Fall 2013

CS 7450

66

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

Fall 2013

CS 7450

67

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

Fall 2013

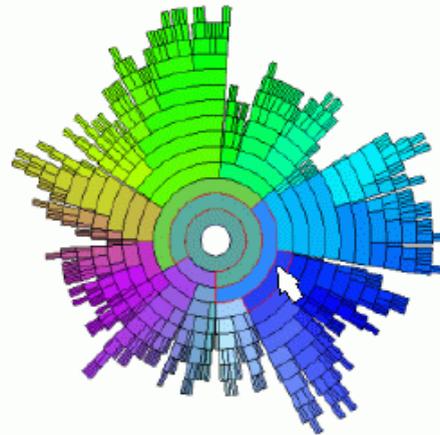
CS 7450

68

InterRing

Provides many of those follow-on capabilities and new operations

Yang, Ward & Rudensteiner
InfoVis '02



Fall 2013

CS 7450

69

Even Sand Crabs Do It



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

Fall 2013

CS 7450

70

Survey of Radial Techniques



IEEE TRANSACTIONS ON VISUALIZATION AND COMPUTER GRAPHICS, VOL. 14, NO. 5, SEPTEMBER/OCTOBER 2008

A Survey of Radial Methods for Information Visualization

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

Abstract—Radial visualization, or the practice of displaying data in a circular or elliptical pattern, is an increasingly common technique in information visualization research. In spite of its prevalence, little work has been done to study the visualization paradigm as a visualization in its own right. This paper is a critical study of radial visualization, focusing on its uses in conventional statistical graphics. We first identify the types of problem domains in which radial visualization techniques have been applied. A taxonomy for radial visualization is proposed in the form of a series of design patterns, representing a variety of recent work in the area. First, a survey of these patterns, we build a series of design considerations that system builders can use to create new radial visualizations that address aspects of the design space that have not yet been explored. We highlight our taxonomy and provide a framework for building interactive design visualizations and advance the development of radial visualizations, and systems enabling radial visualization as a desktop design paradigm.

Index Terms—information visualization, radial visualization, visualization techniques and methodologies, interactive data exploration and discovery.

1 INTRODUCTION

"The goal of information visualization is to communicate technical information in a graphical, interactive, and understandable way. This paper focuses on an emerging paradigm in information visualization, namely, radial visualization. We use the term radial visualization to describe any visualization system that organizes data in a circular or elliptical pattern. Radial visualization is an increasingly popular technique in information visualization and HCI research. Indeed, recent survey papers in the field of interactive visualization make use of radial visualization to at least some extent. Examples include the Wikipedia, Research VUE, Radar, Traffic Analyzer [10], and Vicker [11]. The prevalence of radial visualization is probably due to its aesthetic appeal. In complex domains, an attempt to fit all available data within any such of the user [12]. Whatever the reason, the sheer popularity of the visualization metaphor makes it a subject worthy of further analysis. In several surprising ways, little effort has been devoted to studying radial visualization as a distinct methodology of its own.

The present work aims to fill this identified gap. To our knowledge, this paper is the first such effort to gather, review, and analyze the vast body of research involving radial visualization. We first provide a historical review of radial visualization, tracing its evolution from its origins in the constraints of statistical graphics. We then identify the

principal types of problem domains in which radial visualization techniques have been applied. A taxonomy for radial visualization is proposed in the form of seven design patterns encompassing nearly all recent work in this area. We discuss several examples of such patterns, drawn from both academic and commercial sources. From an analysis of these patterns, we then distill several design dimensions, or considerations, that system builders can use to create new radial visualizations that address aspects of the design space that have not yet been explored. Finally, we suggest possible extensions to research on radial visualization by applying the design patterns and dimensions presented herein to related problem domains.

In closing, we are not suggesting that radial visualization is a panacea for all information visualization problems. Indeed, we hope instead to make the research community's awareness of radial visualization, drawing it from an otherwise visual paradigm to a unique methodology of its own. Information visualization researchers will thus be able to evaluate radial techniques in the context of others, and select whichever visualization metaphor is most appropriate for a given problem.

2 A HISTORY OF RADIAL GRAPHICS IN STATISTICS

The term radial visualization appears to have been coined by Hoffman et al. [13] in the 1970s, but the underlying concepts are fairly ancient in the statistical graphics literature of the 19th century. Indeed, techniques such as the pie chart, sunburst, and radial plot are frequently used to describe the same. In conventional statistical data displays, radial graphics are the common ancestors of virtually all the radial visualization methods found in the rest-of-the-world research, so we begin our survey with them.

2.1 Pie Charts

A radial display is a visualization paradigm in which information is laid out in a circular or elliptical pattern. Hoffman et al. [13] in the 1970s, but the underlying concepts are fairly ancient in the statistical graphics literature of the 19th century. Indeed, techniques such as the pie chart, sunburst, and radial plot are frequently used to describe the same. In conventional statistical data displays, radial graphics are the common ancestors of virtually all the radial visualization methods found in the rest-of-the-world research, so we begin our survey with them.

Draper et al
TVCG '09

Fall 2013

CS 7450

71

More Alternatives

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

Fall 2013

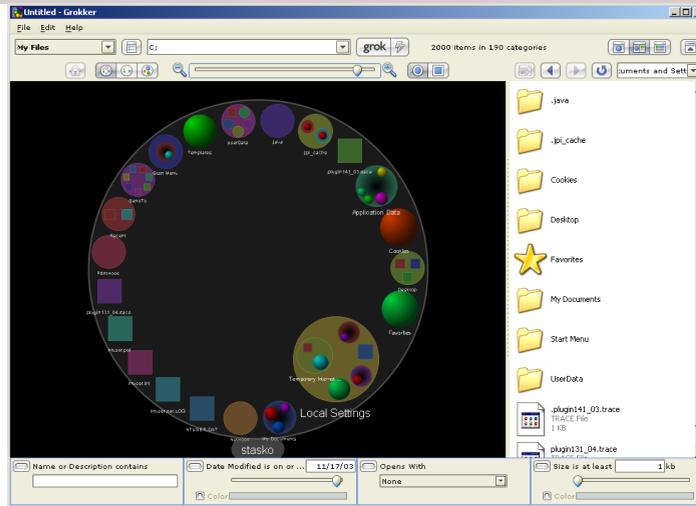
CS 7450

72

Grokker

www.groxis.com

Demo



Fall 2013

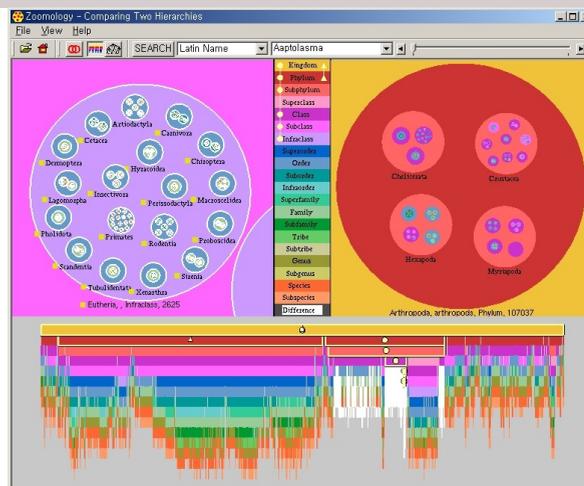
CS 7450

73

Zoomology

CS 7450
Spring '03
project

InfoVis '03
Contest Winner
Best Student
entry

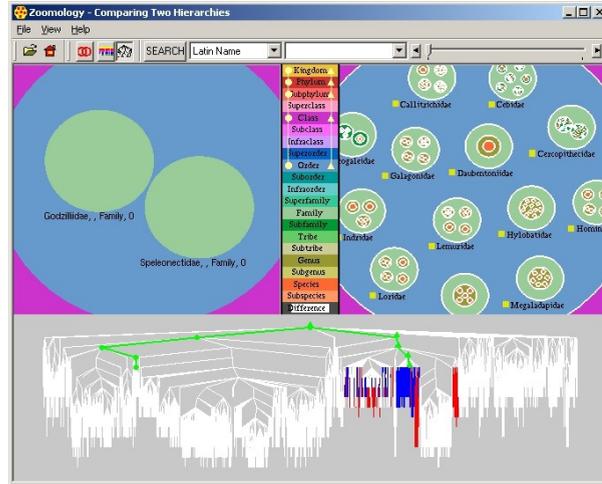


Fall 2013

CS 7450

74

Alternate View



Video

Fall 2013

CS 7450

75

Circle Packing

Wang, Wang, Dai & Wang
CHI '06

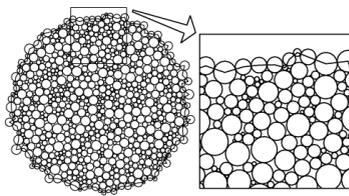


Figure 4. Packing 1000 circles with random radii

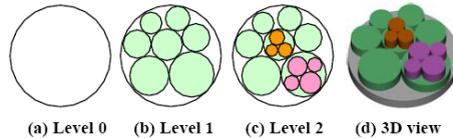
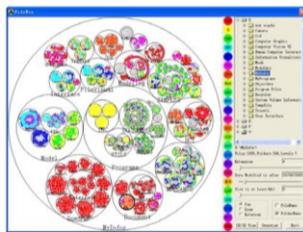
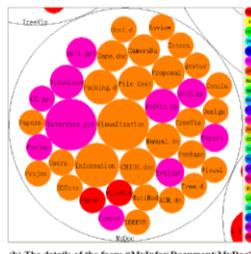


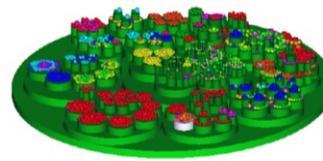
Figure 5. Pack circles into a circle recursively



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



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



(c) 3D nested cylinders and spheres

Fall 2013

CS 7450

76

Hybrid Approaches

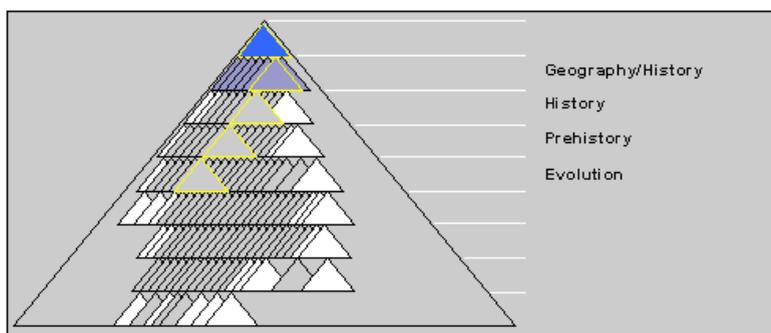
- Mix node-link and space-filling

Fall 2013

CS 7450

77

CHEOPS



(Saw last time)

Beaudoin, Parent, Vroomen,
Vis '96

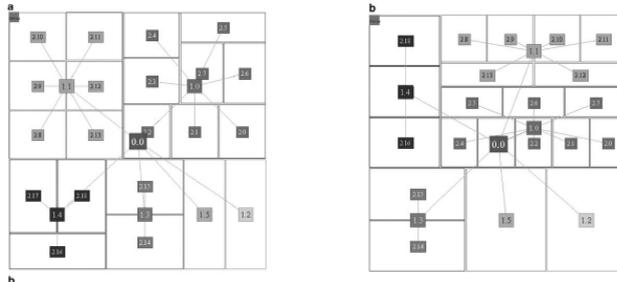
Fall 2013

CS 7450

78



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



Fall 2013

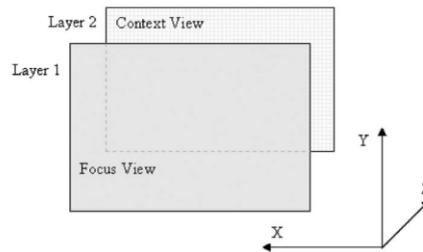
CS 7450

79

Focus + Context → Zooming + Layering



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

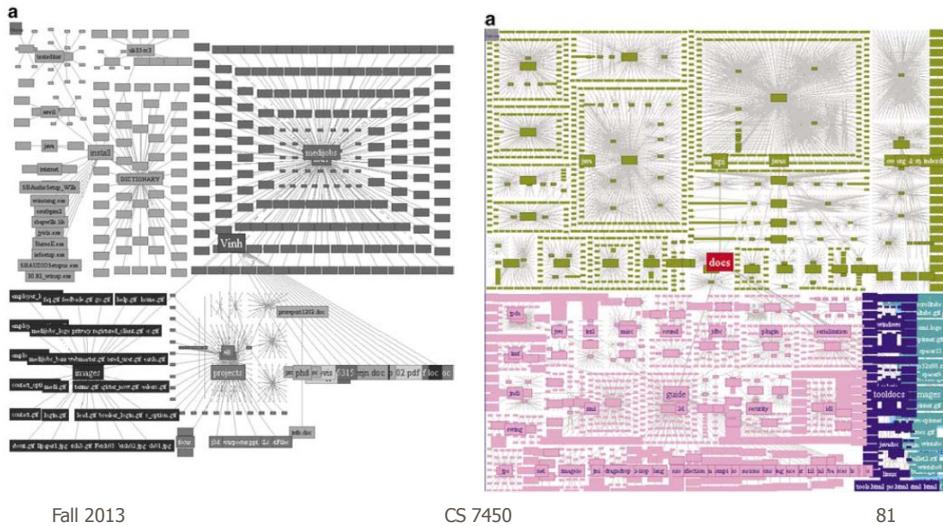


Fall 2013

CS 7450

80

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>

Fall 2013

CS 7450

83

Zoomed In



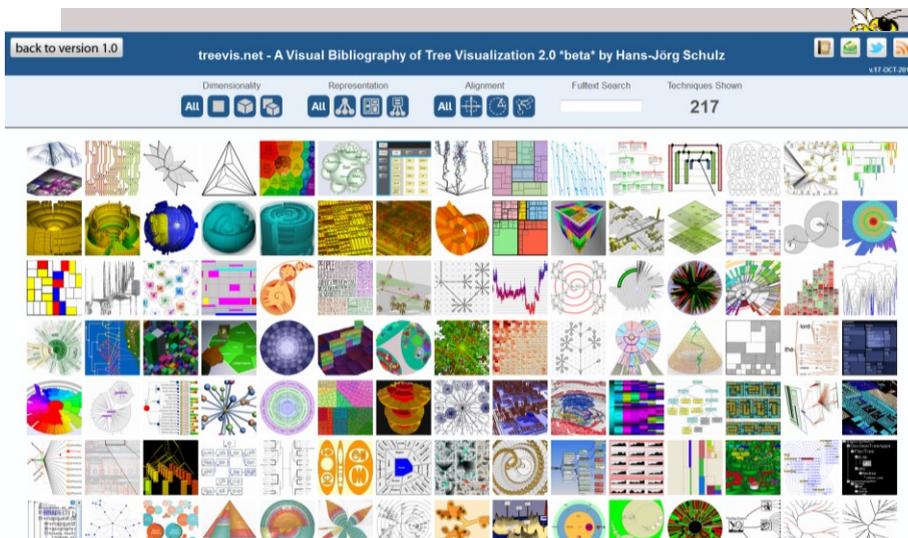
Fall 2013

CS 7450

84

Version 2

<http://treevis.net>



Fall 2013

CS 7450

85

Upcoming

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

Fall 2013

CS 7450

86

References

- Spence and CMS texts
- All referred to papers