Hierarchies and Trees 2
(Space-filling)

CS 4460/7450 - Information Visualization
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Hierarchies

- 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

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

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

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

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

These kinds of rectangles are visually unappealing

Which has bigger area?

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](http://www.smartmoney.com/marketmap)

Image on next slide

Wattenberg
CHI ‘99
A good day :^)
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
R₁ - elements earlier in list than pivot
R₂ - elements in list before R₃ 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

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

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

The Hive Group

www.hivegroup.com/amazon.html
News Stories

Marumushi

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

Investment Portfolios

Panopticon

www.panopticon.com
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

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**Voronoi Treemaps**

Balzer & Deussen
InfoVis ‘05
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
Radial Space-Filling

Chuah
InfoVis '98

Andrews & Heidegger
InfoVis '98
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

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

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
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

Spring 2010
CS 4460/7450

Alternate View

Video

Spring 2010
CS 4460/7450
**Circle Packing**

![Diagram of circle packing](image)

Figure 4. Packing 1000 circles with random radii

![Diagram of level packing](image)

Figure 5. Pack circles into a circle recursively

(a) Level 0  (b) Level 1  (c) Level 2  (d) 3D view

Hybrid Approaches

- Mix node-link and space-filling
CHEOPS

(Saw last class)

Beaudoin, Parent, Vroomen, Vis ’96

EnCon

• 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

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**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

HW 5

- Investigative analysis
  - Documents from t-square
- Due next Tuesday
Upcoming

• Visual analytics
  – Reading
    Keim et al
• Time Series Data
  – Reading
    Aigner et al

References

• Spence and CMS texts
• All referred to papers