Data Visualization (CSCI 627/490)

Trees

Dr. David Koop





Networks

- Network: nodes and edges connecting the nodes
- Formally, G = (V,E) is a set of nodes V and a set of edges E where each edge connects two nodes.
- Nodes == items, edges connect items
- Both nodes and edges may have attributes



Network Data Represented in Tables

Nodes

ID	Atom	Electrons	Protons
0	Ν	7	7
1	С	6	6
2	S	16	16
3	С	6	6
4	Ν	7	7

Edges

ID1	ID2	Bonds
0	1	1
1	2	1
1	3	2
3	4	1

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Networks Need Layouts!

- Need to use spatial position when designing network visualizations
- Otherwise, nodes can **occlude** each other, links hard to distinguish
- How?
 - With bar charts, we could order using an attribute...
 - the data usually)
- Possible metrics:
 - Edge crossings
 - Node overlaps
 - Total area

- With networks, we want to be able to see connectivity and topology (not in





Layout Algorithms



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[Force-Directed and CoLa, M. Bostock]



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Bundling Strength















Adjacency Matrix

- Change network to tabular data and use a matrix representation
- Derived data: nodes are keys, edges are boolean values
- Task: lookup connections, find wellconnected clusters
- Scalability: millions of edges
- Can encode edge weight, too











Structures from Adjacency Matrices













Node-Link or Adjacency Matrix?

- adjacency better for large graphs
- Multi-link paths are hard with adjacency matrices
- Immediate connectivity or neighbors are ok, estimating size (nodes & edges also ok)
- People tend to be more familiar with node-link diagrams
- Link density is a problem with node-link but not with adjacency matrices

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• Empirical study: For most tasks, node-link is better for small graphs and







- Working through grading these to provide feedback
- Initial Feedback
 - Some tasks are not tasks
 - Some tasks are technically tasks but are phrased in terms of a visualization - Think about the question "Why would someone care?"
- Example: Is there a correlation between the season and types of storms in regions?
 - Who cares?
 - Why do they care?
 - Are there specific instances where we can see how people might use info?





- Next steps:
 - Start thinking about the designs that help answer the questions
 - Tasks should drive your design
 - Different designs are great
 - Multiple views
 - Single view with details on demand
 - Interaction design (linked highlighting, navigation)
 - In general, don't force the user to make choices without first seeing an overview





Assignment 4







Irees

- Trees are directed acyclic networks
 - each edge has a direction: the origin is the parent, the destination is the child
 - cannot get back to a node after leaving it
- ...plus each node has at most one parent node
- A tree has a **root** (every other node hangs off it)
- Can consider enclosure in trees using parent-child relationships





Tree Visualizations



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Η

G





Node-Link Diagram

- Trees are graphs
- ...but we have more structure
- Horizontal or vertical
- Idea 1: partition space for each node via recursion
- Idea 2: "Tidy" Drawing
 - Wetherell & Shannon: Don't waste space (overlapping parent nodes is ok)
 - Reingold and Tilford: Keep symmetry, subtrees look similar



Reingold-Tilford Algorithm



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- Recurse on left and right subtrees
- Shift subtree over as long as it doesn't overlap
- Place parent centered above the subtrees
- Originally, only binary trees, extended by Walker









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Icicle Plot

- Line marks
- Vertical position shows depth
- Horizontal position shows links and sibling order
- Scalability: 1 pixel leaves, but harder to label













Radial Node-Link

- Use polar coordinates instead of rectilinear
- Same layout algorithms work (e.g. Reingold-Tilford)
- Benefit: space usage, labels

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Sunburst

- Icicle plot in a radial layout
- Reading labels?
- Intuitive navigation





Indented Outline



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Like a filesystem tree

 Use horizontal position to show depth, vertical positions show sibling/order









Treemap

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Car/Truck Treemap

Truck Sales Slip, Tripping Up Chrysler

Over the past few years, Chrysler executives said they were following the lead of Toyota and Honda, focusing on vehicles that met the needs of their customers. But as American consumers turned away from large trucks and S.U.V.'s in 2006, Chrysler continued to churn out big vehicles, which are now sitting unsold at dealerships across the country.



General Motors

shifted to cars.

Cars

Dodge

Ram

Trucks/vans/S.U.V.'s 2.5 million 1.6 million Cars

G.M. introduced new versions of its large S.U.V.'s in late 2005, hoping they would bolster sales. Instead, sales of big vehicles were hurt when gas prices climbed. One of the few standouts was the Chevrolet HHR, new in 2005.



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Chevrolet

-8.7%



READING THE CHART

Boxes are scaled proportionally 25,000 according to number of cars 100,000 sold in 2006



were introduced in 2005.

lodge Saliber 12,224		
kge ktus 993		

Toyota Tacoma 178,351	Toyota Sienna 163,269	Toyota Camry 448,645		Toyota Coroli 387,388	A	
Toyota RAV4 152,047	Toyota Highlander 129,794					
Toyota Tundra 124,508	Toyota 4Runner 103,086	Toyota Prius 106,971	Scion tC 79,125	Toyota Yari 70,308		on xB 306
Lexus FIX 108,348	Toyota FJ Cruiser 56,225 24,315	Toyota Avalon 88,938	Lexus ES 75,987	54,267	Scion xA 32,603	Lexus GS 27,390



Toyota Trucks/vans/S.U.V.'s 1.1 million Cars

Toyota rolled out a new version of the Camry, and once again it was the country's best-selling car.



Corolla sales also jumped, along with gas prices. Toyota could not escape the decline in sales of supersized S.U.V.'s like its Sequoia.

Honda

Trucks/vans/S.U.V.'s 0.7 million Cars

Like the Corolla, the small Honda Civic did well. But the Accord stalled. Buyers, it seems, are waiting for the new version to be released this year.



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Car/Truck Treemap

Ford

-8.3%

Trucks/vans/S.U.V.'s 1.8 million 1.1 million Cars

Even the country's best-selling vehicles, the F-Series, slumped in 2006, with sales dropping 13 percent. One of Ford's bright spots was the new Fusion sedan, which made its debut in late 2005 and sold well in its first full year.

Ford F-Series

Ford F-Series 744,996	Ford Econoline 180,457	1	Ford Exp 179,229	lorer	Ford Focus 177,006		Ford Taurus 174,803
	Ford Escape 157,395			rd Ranger 420	Ford Mustang 166,530		Ford Fusion 142,502
	Ford Expedition 87,203	Ford F 50,125	Areostar 5	Mercury Mariner 33,941	Ford Five Hundred 84,218	Mercury Grand Marquis	Marcury Milan 35,653
	Ford Freestyle 58,602	Valvo XC90 33,200 Mercu	Navig 23,94	pator	Ford Crown Victoria 62,976	54,685 Lincoln Town Ca 39,295	Volvo S40 24,566

READING THE CHART





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Many of these vehicles were introduced in 2005

[A. Cox and H. Fairfield, NYTimes, 2012]





0.3 million +10.3%

+2.1%

0.2 million

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Treemap

- Containment marks instead of connection marks • Encodes some attribute of the items as the **size** of the rectangles Not as easy to see the intermediate rectangles

- Scalability: millions of leaf nodes and links possible
- Need a layout algorithm!







Layout Algorithms

- How do we generate the area marks?
- What considerations should we try to keep in mind?







Layout Algorithms

- How do we generate the area marks?
- What considerations should we try to keep in mind?
 - area true to quantitative value
 - show hierarchy
 - aspect ratio
- Also...
 - ordering
 - stability









Treemap Layouts: Slice

- Just divide horizontally
- Dice is similar, just vertical
- Problem: Bad aspect ratio!
 - Very skinny rectangles
 - Makes it harder to compare sizes, see labels, select rectangles
 - Want rectangles that are closer to squares
 - Aspect ratio = width/height

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Treemap Layouts: Slice & Dice

- Split at each level into strips
- At each step, orientation of division (horizontal/vertical) changes
- Better, but some rectangles still have bad aspect ratio

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Treemap Layouts: Strip

- Consider aspect ratio when adding rectangles
- Do one row at a time by processing rectangles in sorted order by size
 - Check if adding the next rectangle to the row improves aspect ratio
 - When it doesn't, go to next row
- Problem: Last rectangles have bad aspect ratios
- Solution: Look ahead to decide if would be better to add to previous row

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Treemap Layouts: Squarify

- Slice & Dice and Strip can lead to bad aspect ratios
- Solution: Strip only uses rows, allow columns to be used, too
- Choose divisions (x/y) based on the width/height of region in order to maintain good aspect ratios
 - Use left and right side
 - Process large rectangles first
- Ordering not preserved which may cause issues if the data is updated

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Squarification Algorithm











Squarification Algorithm













Squarified Treemaps



(a) File system

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(b) Organization













Squarified Layout

- Sort values
- Switch orientation whenever necessary to obtain best aspect ratios







Improving Treemaps (Cushion)

- Leaves are ok, but it can be difficult to find the hierarchy
- Encode this as shading information
- More effective to understand hierarchy



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[van Wijk and van de Wetering, 1999]



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Disk Inventory

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▶ 📁 Resources	21,5 MB	
NetServices	5,7 MB	
V MacOS	2,2 MB	
iPhoto	1,9 MB	
iPhotoDPA	273 kB	
photocd	70 kB	
Plugins	1,7 MB	
DS_Store	6 kB	
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Info.plist	1 kB	
version.plist	463 Byte	
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-	Interface Builder Docum	15,4 MB	2104
-	MP3 Audio File	4,8 MB	2
	Unix Executable File	3,8 MB	23
	JPEG Image	1,6 MB	74
	Strings File	1,4 MB	348
-	HTML document	1,3 MB	333
-	TIFF Document	1,0 MB	310
-	Document	886 kB	16
-	Portable Network Graphi	635 kB	21
-	XML Property List File	183 kB	332
-	Apple Icon Image	109 kB	2
-	AIFF Audio	67 kB	2
	Finder Document	65 kB	1
	Script	35 kB	5
	Rich Text Format (RTF) d	30 kB	2
	AppleScript Suite Definit	7 kB	1
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	Graphics Interchange Fo	5 kB	12
	Cascading Style Sheet (C	4 kB	4
	Symbolic Link	164 Byte	9











Squarified + Cushioned Treemaps



(a) File system

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(b) Organization









Variations: Marimekko Chart









Nested Circles

- Looks more like cluster diagram, but shows hierarchy
- Containment shown by the layering of semi-transparent circles
- Labeling becomes more difficult













Compound Networks

- Add a hierarchy to the network (e.g. from clustering)
- GrouseFlocks: uses nested circles with colors



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