Data Visualization (CSCI 627/490)

Trees

Dr. David Koop





Choropleth (Two Hues)



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Choropleth (Diverging Attribute)











Don't Just Create Population Maps!





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PET PEEVE #208: GEOGRAPHIC PROFILE MAPS WHICH ARE BASICALLY JUST POPULATION MAPS









House Races: Non-Contiguous "Cartogram"













Maps Aren't Always Best: Close House Races

12 Lean Democratic

- AZ-02 Open (McSally)
- CA-49 Open (Issa)
- CO-06 Coffman
- IA-01 Blum
- KS-03 Yoder
- MI-11 Open (Trott)
- MN-02 Lewis
- MN-03 Paulsen
- NV-03 Open (Rosen)
- NJ-11 Open (Frelinghuysen)
- PA-07 Vacant (formerly Dent)
- VA-10 Comstock

31 Tossups

- CA-10 Denham
- CA-25 Knight
- CA-45 Walters
- FL-26
- FL-27
- IL-06
- IL-12
- IA-03
- KY-06 Barr

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- CA-39 Open (Royce)
- CA-48 Rohrabacher
 - Curbelo
 - Open (Ros-Lehtinen)
 - Roskam
 - Bost
 - Young
- KS-02 Open (Jenkins)

25 Lean Republicar

- AR-02 Hill
- CA-50 Hunter
- FL-15 Open (Ross)
- FL-16 Buchanan
- GA-06 Handel
- GA-07 Woodall
- IL-13 Davis
- IL-14 Hultgren
- MO-02 Wagner
- MT-AL Gianforte
- NE-02 Bacon
- NY-24
 - Katko [New York Times, 2018]









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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Project Proposal

- Two Possibilities:
 - Create an interactive visualization
 - Work on a research project
- Dataset Choices
 - US Food Safety Data
 - Illinois Hospital Report Card
 - NFL Data
 - US Register of Introduced and Invasive Species
 - Others?
- Proposal Due Wednesday







Assignment 4

• To be announced soon





Wednesday

- Online Video Lecture
- Have external meeting
- shifted in current agenda
- Office Hours shifted to the afternoon 2-3:15pm

• Was told I was going to have a break during this class time but timing was





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





Force-Directed Layout

- Nodes push away from each other but edges are springs that pull them together • Weakness: nondeterminism, algorithm may produce difference results each time it runs









Constraint-Based Optimization (CoLa)

- Higher quality layout
- More **stable** in interactive applications (no "jitter")
- Allows user specified constraints such as alignments and grouping
- Can avoid overlapping nodes
- Provides flow layout for directed graphs
- May be less scalable to very large graphs
- Can route edges around nodes

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[T. Dwyer et al. (WebCoLa); M. Bostock (Example), 2018]



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sfdp



JGD_Homology@cis-n4c6-b14. 7220 nodes, 13800 edges.







"Hairball"



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JGD_Homology@cis-n4c6-b4. 26028 nodes, 100290 edges.





Hierarchical Edge Bundling









Hierarchical Edge Bundling



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Hierarchical Edge Bundling

- Flexible and generic method
- - information
 - explicit adjacency edges between their respective child nodes

 Reduces visual clutter when dealing with large numbers of adjacency edges Provides an intuitive and continuous way to control the strength of bundling. - Low bundling strength mainly provides low-level, node-to-node connectivity

- High bundling strength provides high-level information as well by implicit visualization of adjacency edges between parent nodes that are the result of











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













Cliques in Adjacency Matrices

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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







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



- 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















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 Corola 387,388	1	
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 x8 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



+12.5% Toyota Trucks/vans/S.U.V.'s 1.1 million 1.5 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 0.8 million

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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Toyota

+3.2%



Car/Truck Treemap

shifted to cars.





General Motors

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

-8.7%

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.



The Chevrolet Impala, with or without flashing lights, did well in 2006, when a redesign came out.

Chevrolet Silverado 636,069						Sierra 36	Chevrolet Impala 289,868			Chevrolet 211,449	
Chevrolet Trai Blazer 174,797	Chevrolet Equinox 113,888		Chovrolo HHR 101,298	d	Col	evrolet Iorado 876	Chevrolet I 163,853	Malibu	I	Pontiac 157,64	
Chevrolet Tahoe 161,491	Saturn Vue 88,581	GMC 71,47	Yukon 16	Chevr Uplan 58,69	der	Chevrolet Avalanche 57,076	Pontiac Grand Prix 106,634		Satum 102,04		Buis Luce 96,5
	Chevrolet Suburban 77,211	Hum H3 54		Pontac Torran	t	Cadillac Escalade	Buick ART	Ca	dillac	Pontiac	
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Ford Trucks/vans/S.U.V.'s 1

	Ford F-Series 744,996	Ford Econoline 180,457	Ford Explorer 179,229	Ford Focus 177,008	Ford Taurus 174,803
1.8 million					

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Toyota Tundra 124,508	Toyota 4Runnar 103,086	Toyota Prius 106,971	Scion tC 79,125	Toyota Yari: 70,308	s Solor 61,30	
Lexus FIX 108,348	Toyota FJ Cruiser Sequoia 56,225 34,315	Toyota Avalon 88,938	Lexus ES 75,987	54,267	Scion xA 32,603	Lexu GS 27,39

Cobalt





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.



Nissan Trucks/vans/S.U.V.'s 0.5 million Cars 0.6 million

BMW Trucks/vans/S.U.V.'s 0.1 million Cars

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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?

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ks? 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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Spring 2213







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



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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]



Northern Illinois University





Disk Inventory

om In Zoom Out Mo	ve To Trash	Show Package Contents
Name	Size	
🔻 🧊 Contents	31,3 MB	A DECISION OF A DECISIONO OF A DEC
▶ 📁 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	
🕨 🧊 PlugIns Disabl	6 kB	
Info.plist	1 kB	
version.plist	463 Byte	
PkgInfo	8 Bytes	
Resources Dis	0 Bytes	
S Icon	65 kB	
DS_Store	6 kB	
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Color	Kind	Size	Files
-	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
	AppleScript Suite Termin	6 kB	1
	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





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