Visual Analytics Primer 2

TODAY!

- Review/Highlights
- Class Exercise
- Data
- A Taxonomy of Representation
  -A detailed listing of data representations
  -(also see http://www.datavizcatalogue.com/
  and http://www.visual-literacy.org/periodic_table/periodic_table.html
  and http://queue.acm.org/detail.cfm?id=2146416)

Jacques Bertin: *Semiology of Graphics, 1967*

Visual Variables

- **position**
  - changes in the x, y, (z) location

- **size**
  - change in length, area or repetition

- **shape**
  - infinite number of shapes

- **value**
  - changes from light to dark

- **orientation**
  - changes in alignment

- **colour**
  - changes in hue at a given value

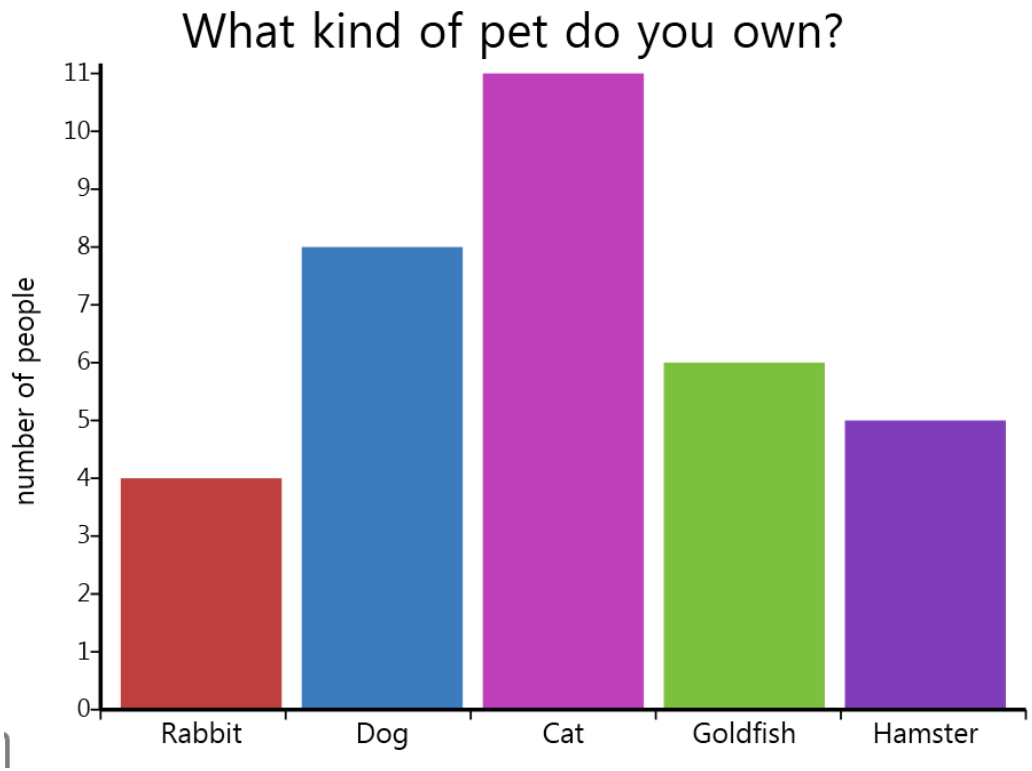
- **texture**
  - variation in pattern

- **motion**

Graphic by: Sheelagh Carpendale

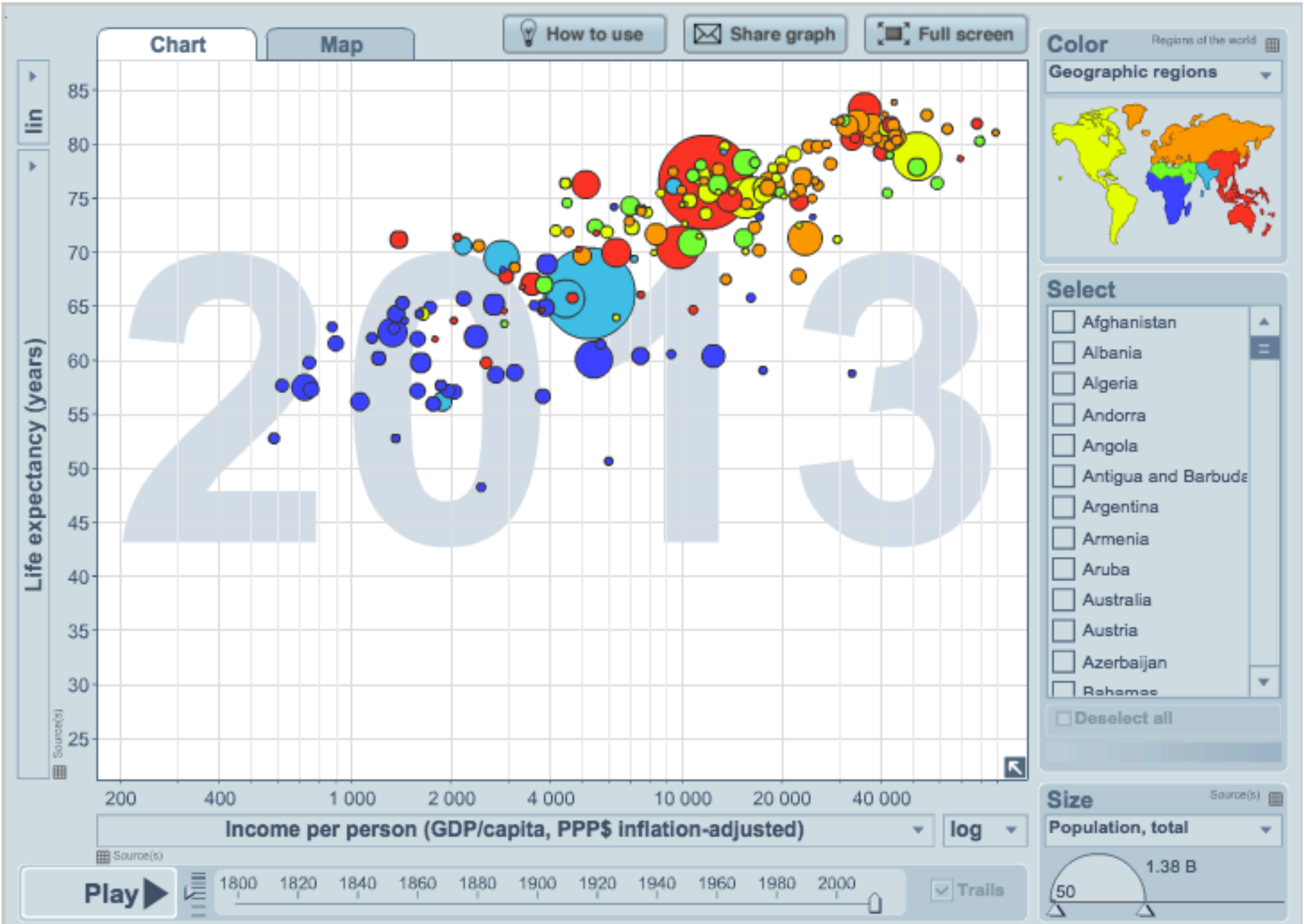
Data mapping

- One or two dimensional data: easy. Example: Simple bar graph



- Multi-dimensional data: more tricky
  - Map each data dimension to a different visual variable
  - Chose visual variables that suit data type
  - Avoid interference with pre-attentive perception
  - Map primary data to primary visual feature; secondary to secondary, etc

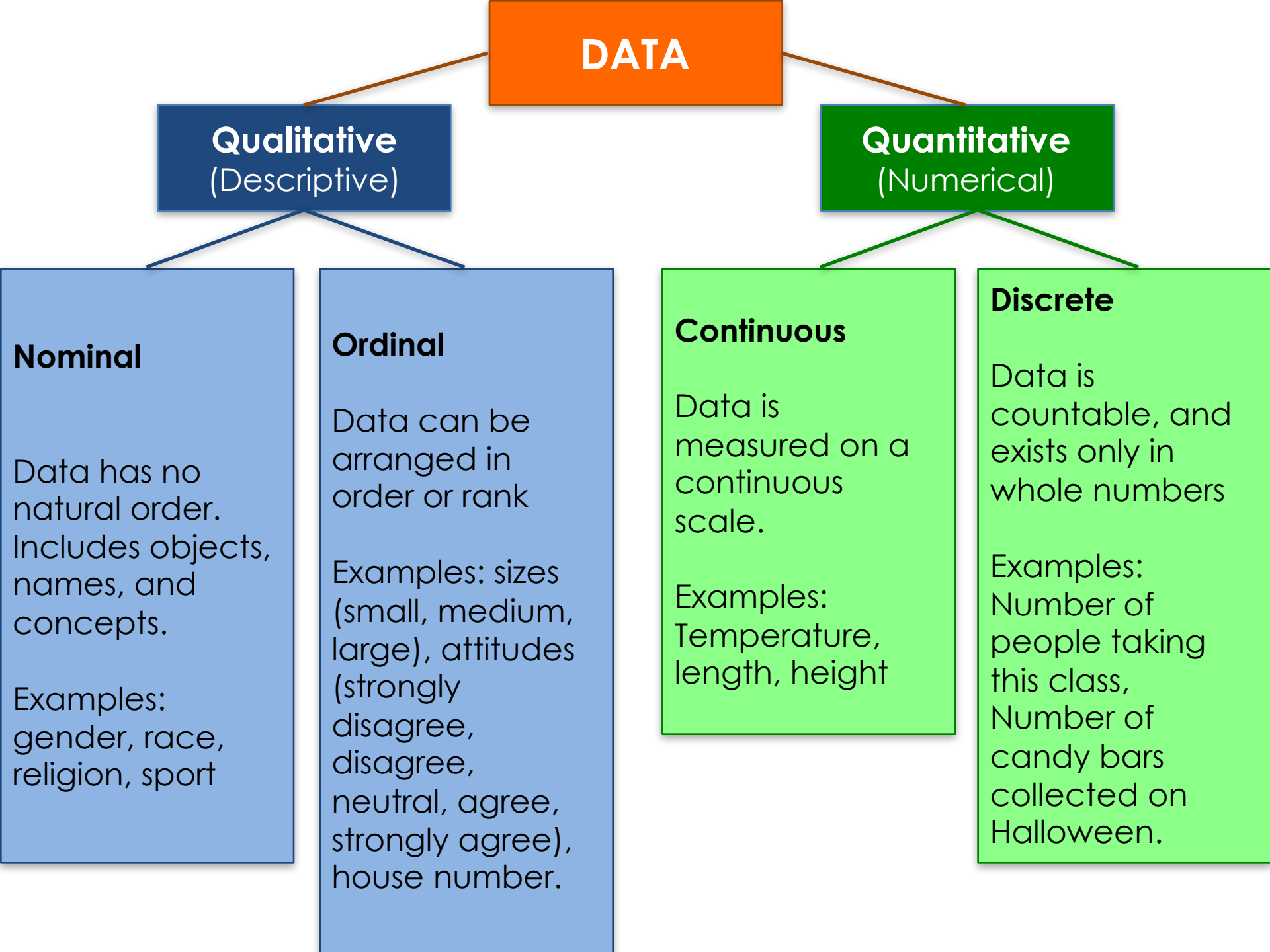
Multidimensional Data Mapping Example: Gapminder.org

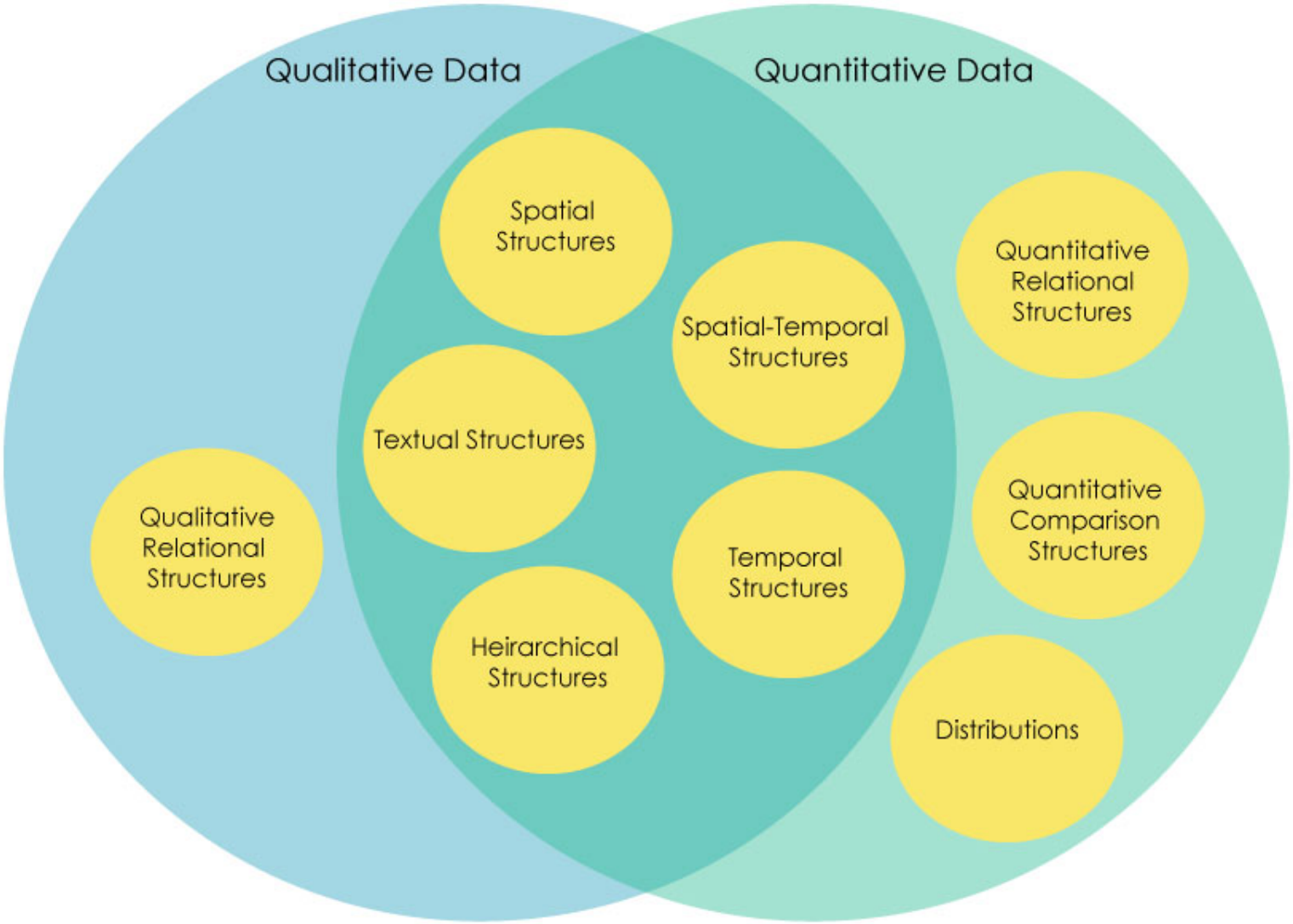


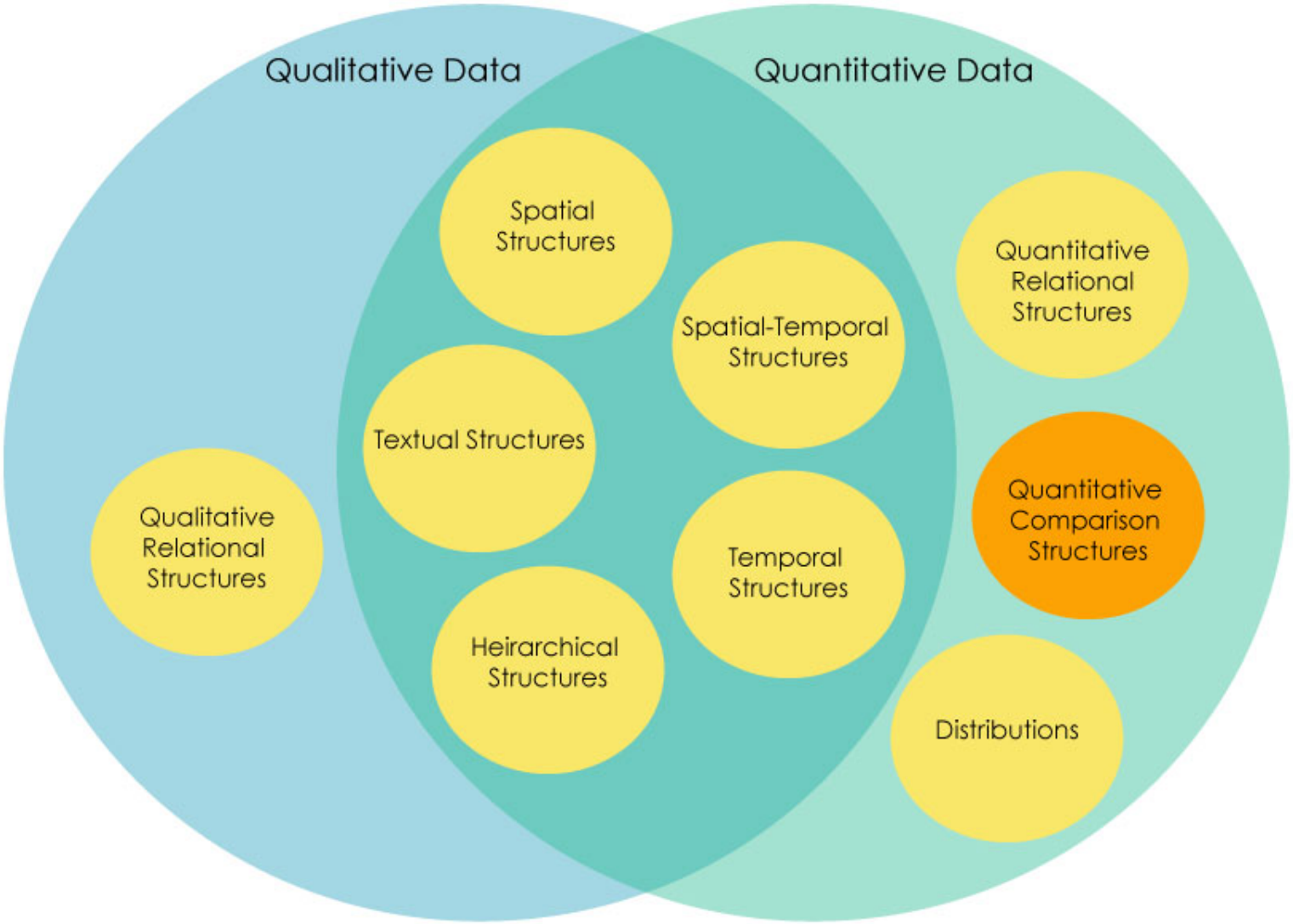
Class Exercise: Visualize this!

37

75


DATA
Qualitative
(Descriptive)
Quantitative
(Numerical)
Nominal
Data has no natural order. Includes objects, names, and concepts.
Examples: gender, race, religion, sport
Ordinal
Data can be arranged in order or rank
Examples: sizes (small, medium, large), attitudes (strongly disagree, disagree, neutral, agree, strongly agree), house number.
Continuous
Data is measured on a continuous scale.
Examples: Temperature, length, height
Discrete
Data is countable, and exists only in whole numbers
Examples: Number of people taking this class, Number of candy bars collected on Halloween.


Qualitative Data
Quantitative Data
Spatial Structures
Spatial-Temporal Structures
Quantitative Relational Structures
Textual Structures
Quantitative Comparison Structures
Qualitative Relational Structures
Temporal Structures
Heirarchical Structures
Distributions


Qualitative Data
Quantitative Data
Spatial Structures
Spatial-Temporal Structures
Quantitative Relational Structures
Textual Structures
Quantitative Comparison Structures
Qualitative Relational Structures
Temporal Structures
Heirarchical Structures
Distributions

Pie Chart

Use sparingly
No more than six components.
Not useful when values of each component are similar

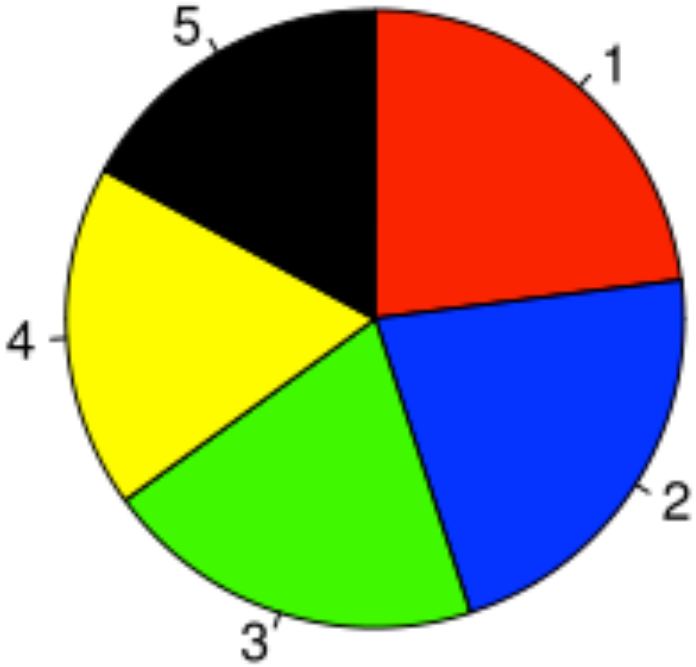


Image source: https://eagereyes.org/techniques/pie-charts

Quantitative Comparison

Doughnut Chart - Bad Idea, in general

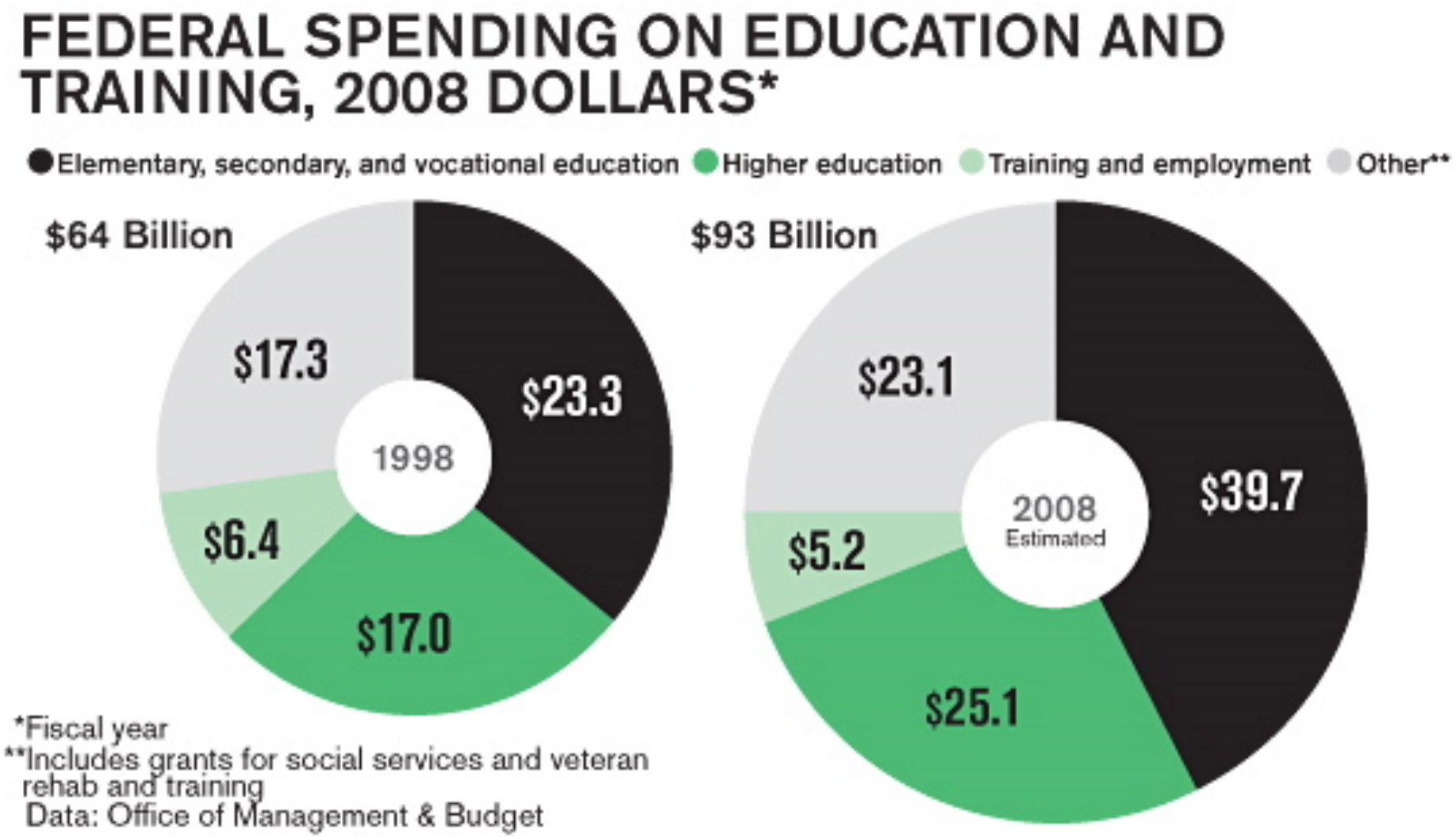
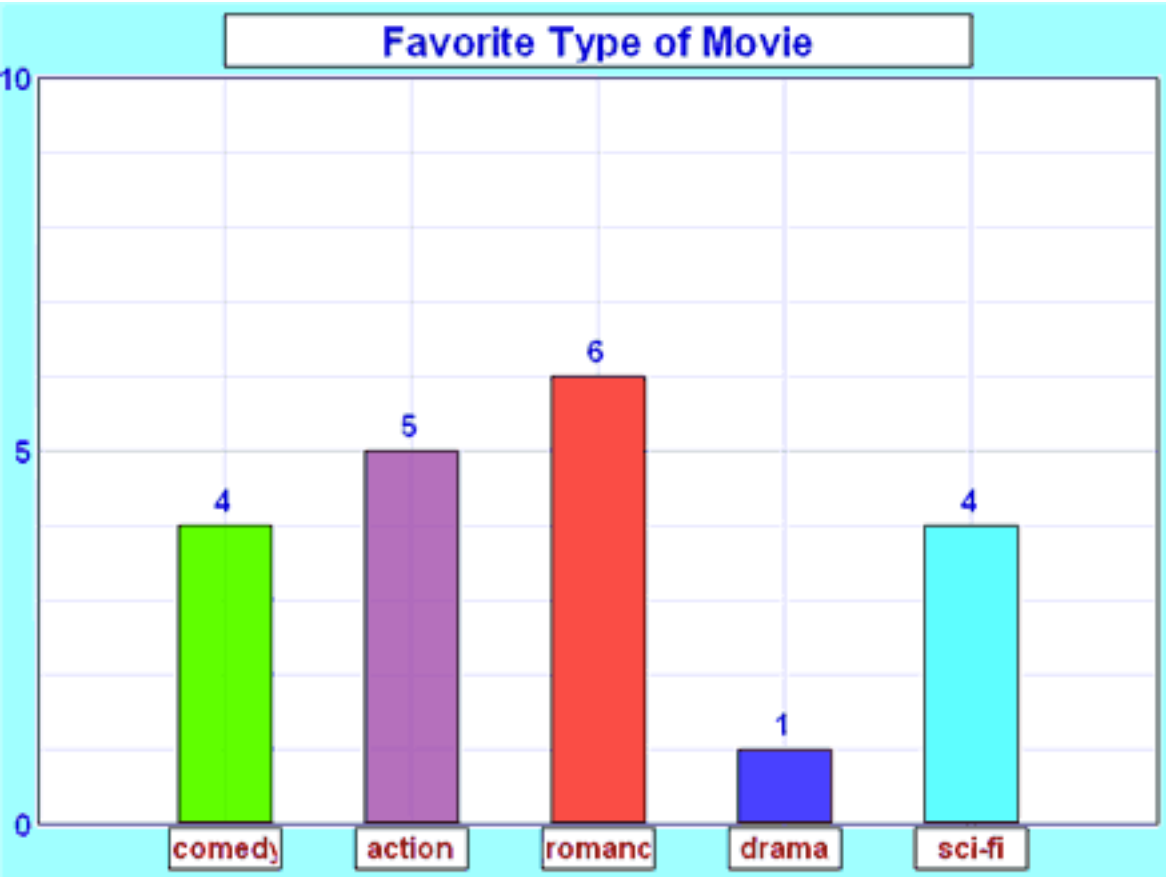


Image source: https://eagereyes.org/techniques/pie-charts

Quantitative Comparison

Bar graph

Best for comparing categories.



Best Practices
Make bars and columns wider than the space between them.

Do not allow grid lines to pass through columns or bars.

Use a single font type on a graph.

Use a single color for the bars.

Image source: https://www.mathsisfun.com/data/bar-graphs.html

Quantitative Comparison

Stacked bar graph

Order your shade pattern from darkest to lightest on stacked bar graphs.

Avoid patterns.

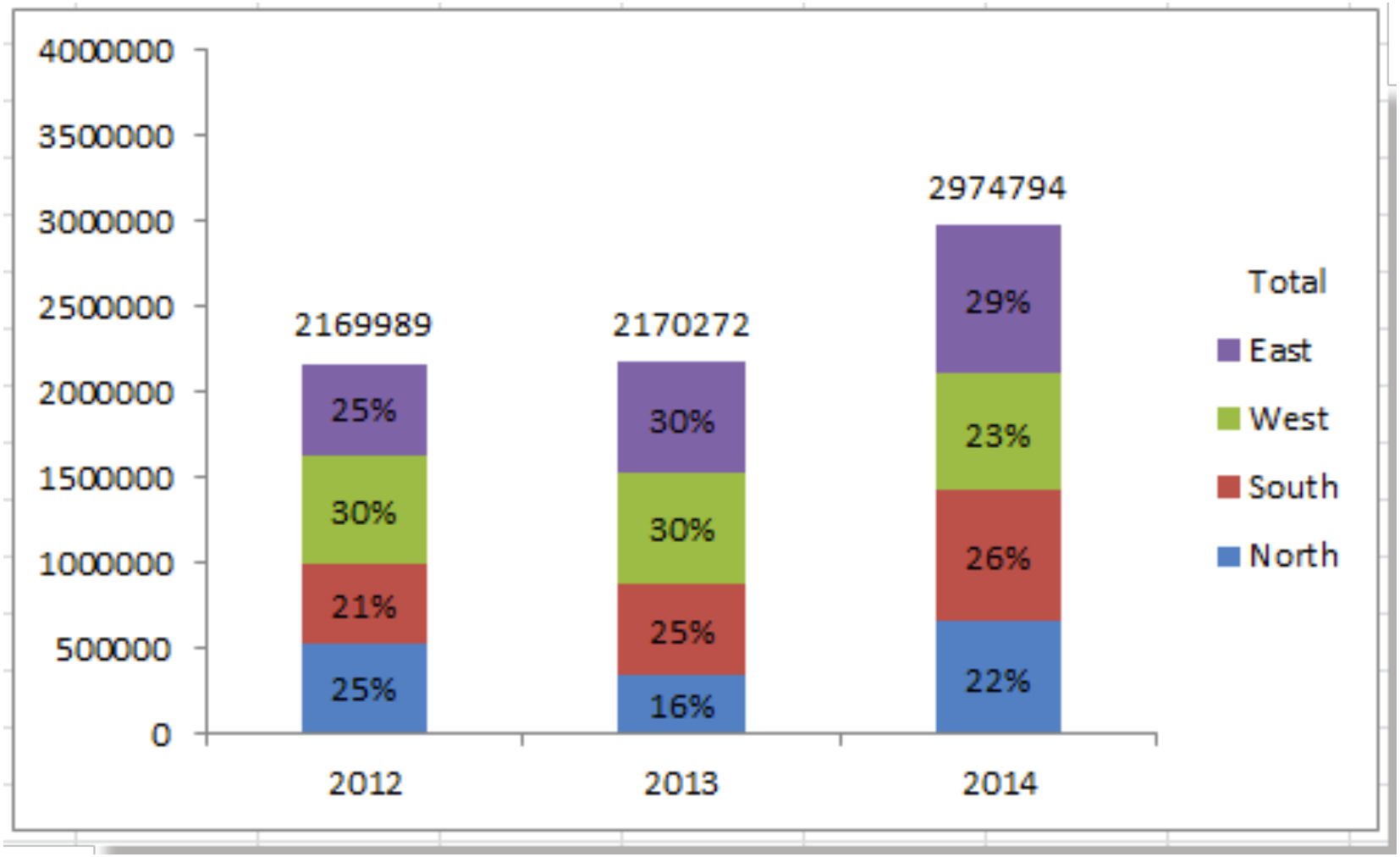
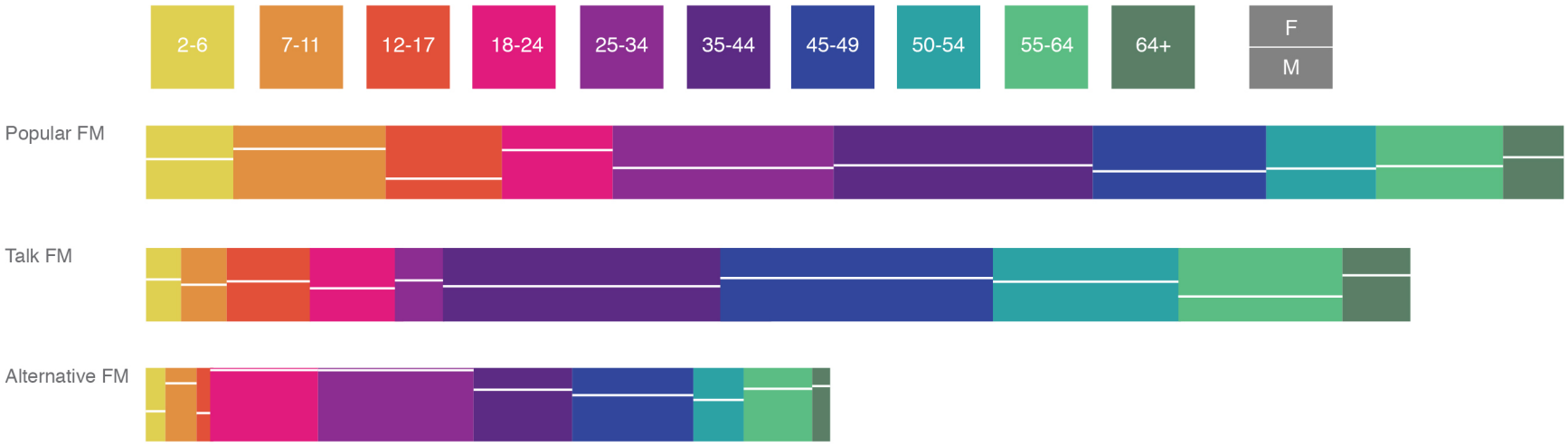


Image Source:
http://www.extendoffice.com/documents/excel/2370-excel-show-percentages-in-stacked-column.html

Quantitative Comparison

Stacked-stacked bar graph



Quantitative Comparison

Clustered bar graph

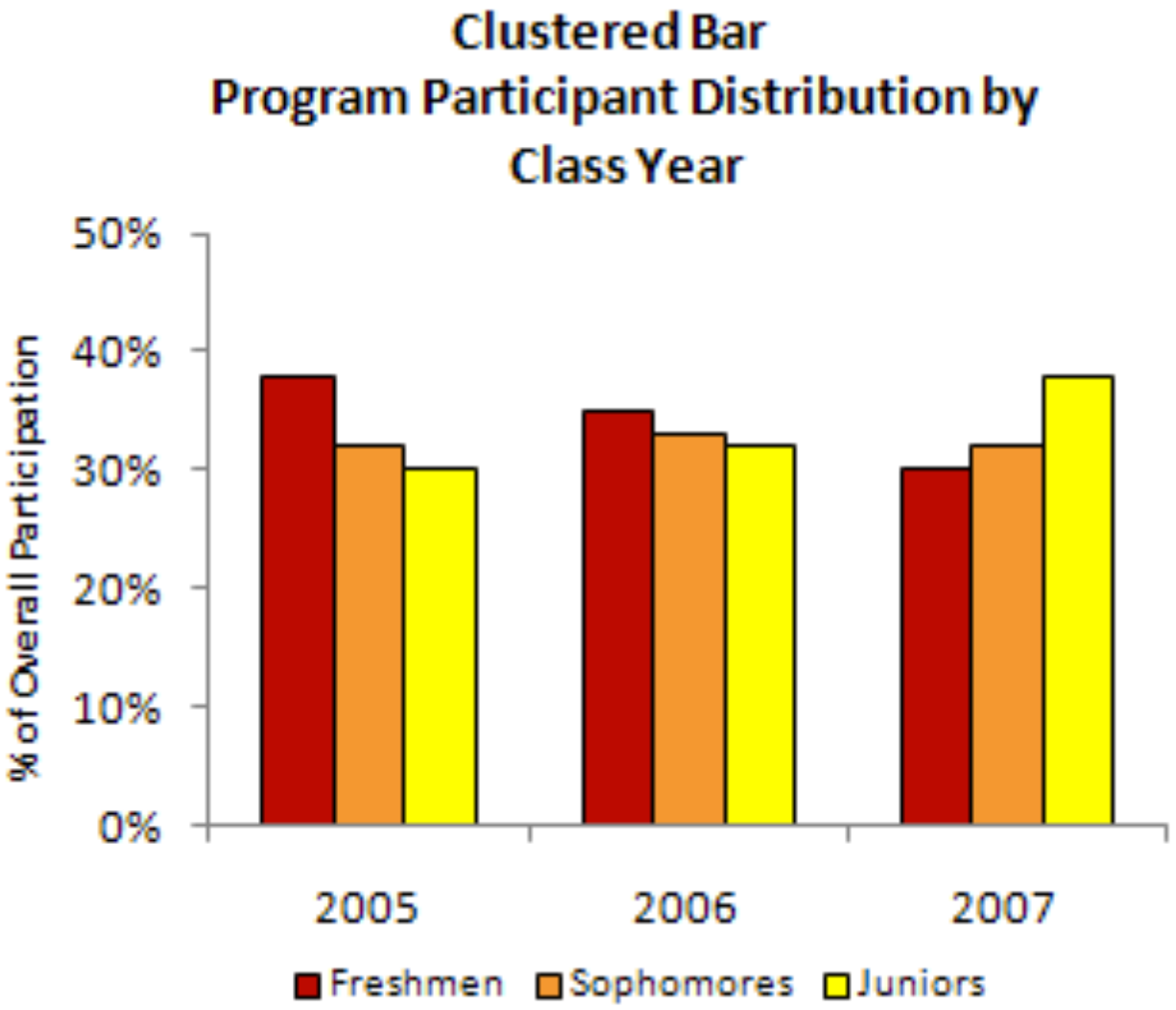


Image Source: http://virg.vanderbilt.edu/AssessmentPlans/Results/Reporting_Results_Quantitative.aspx

Quantitative Comparison

Bubble Charts

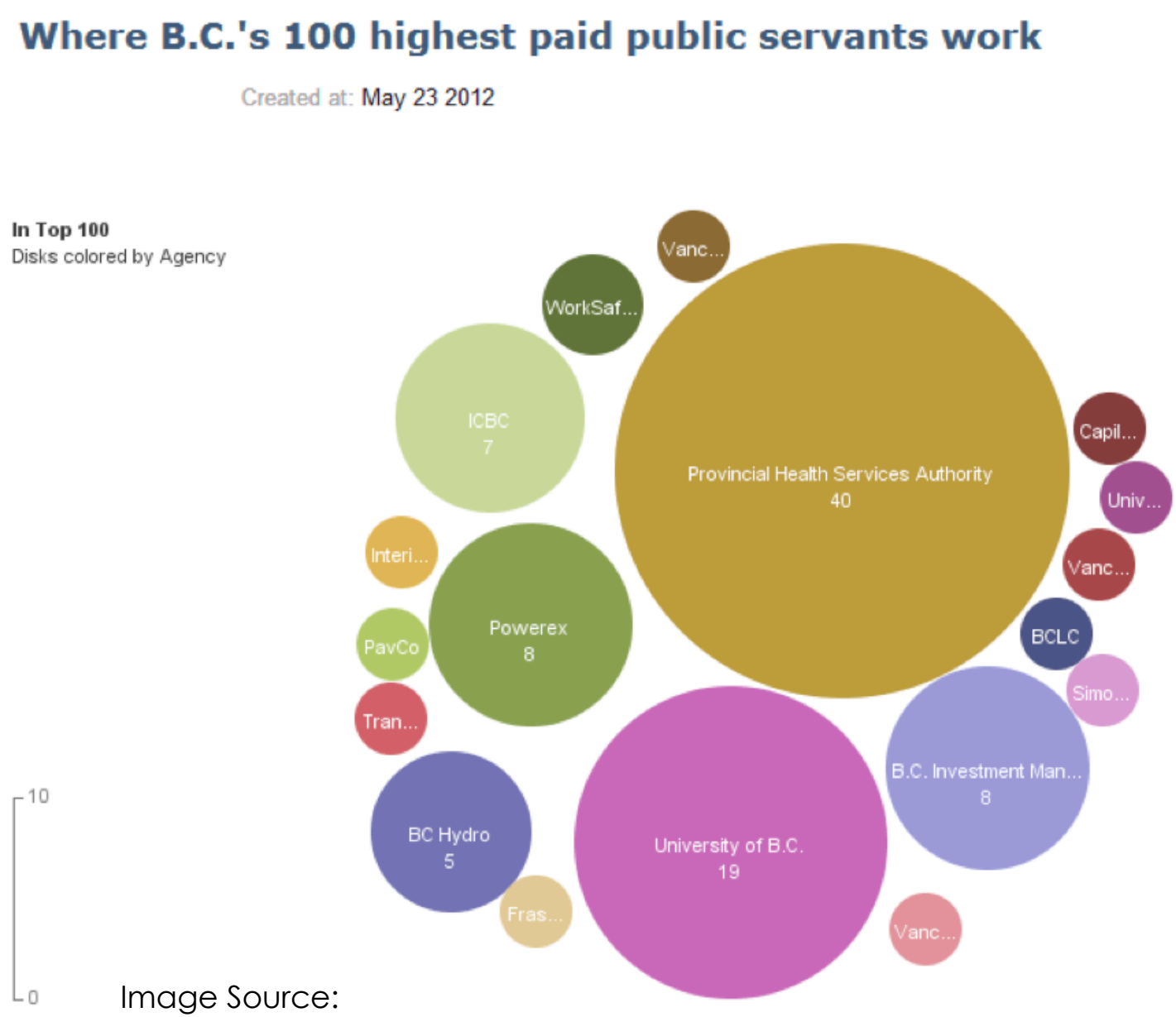
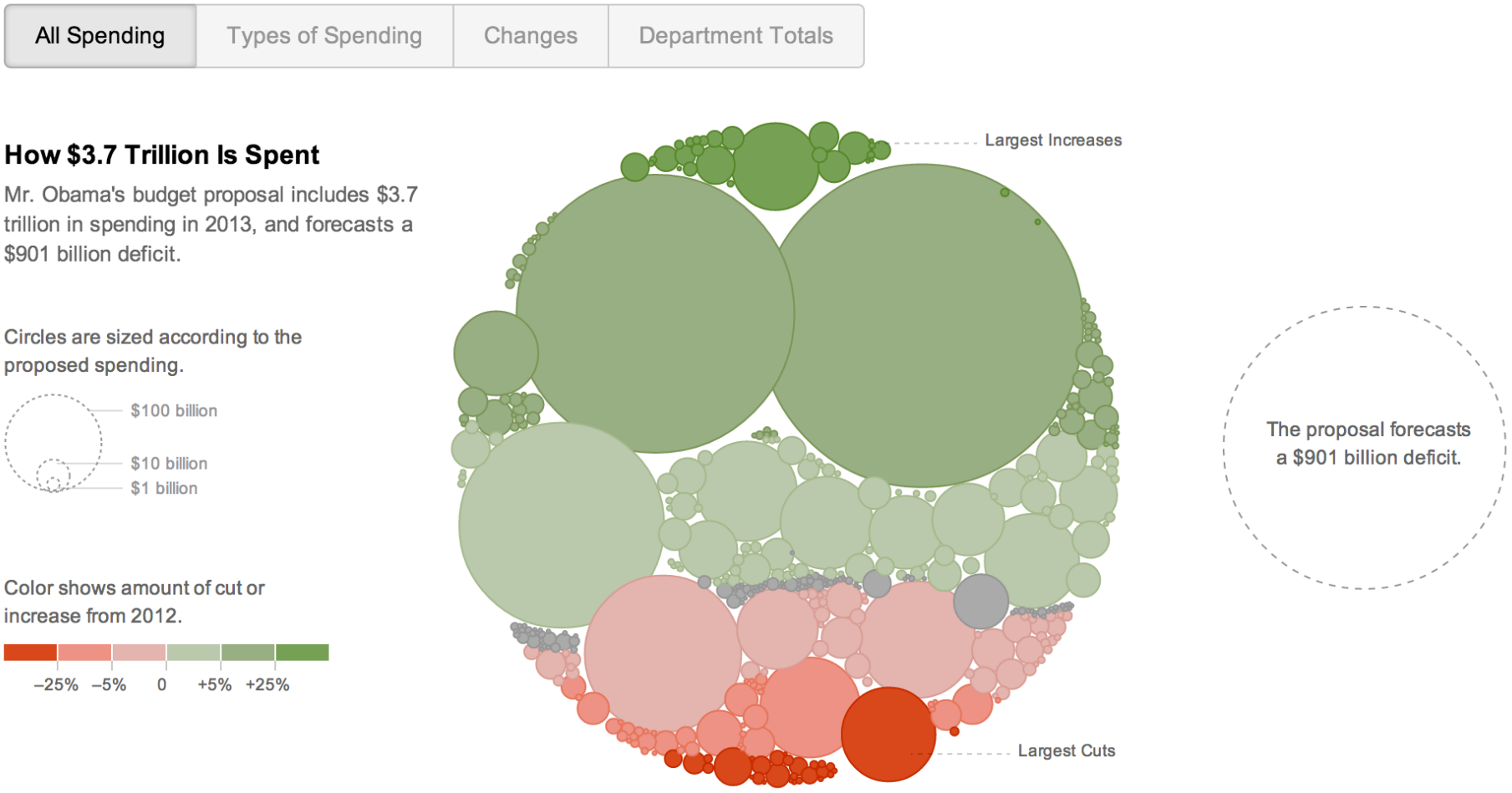


Image Source:
http://www.perceptualedge.com/blog/wp-content/uploads/2013/04/packed-bubble-chart.png

Quantitative Comparison

Bubble Charts



http://www.nytimes.com/interactive/2012/02/13/us/politics/2013-budget-proposal-graphic.html?_r=1&

Quantitative Comparison

Pictogram Chart

For discrete data

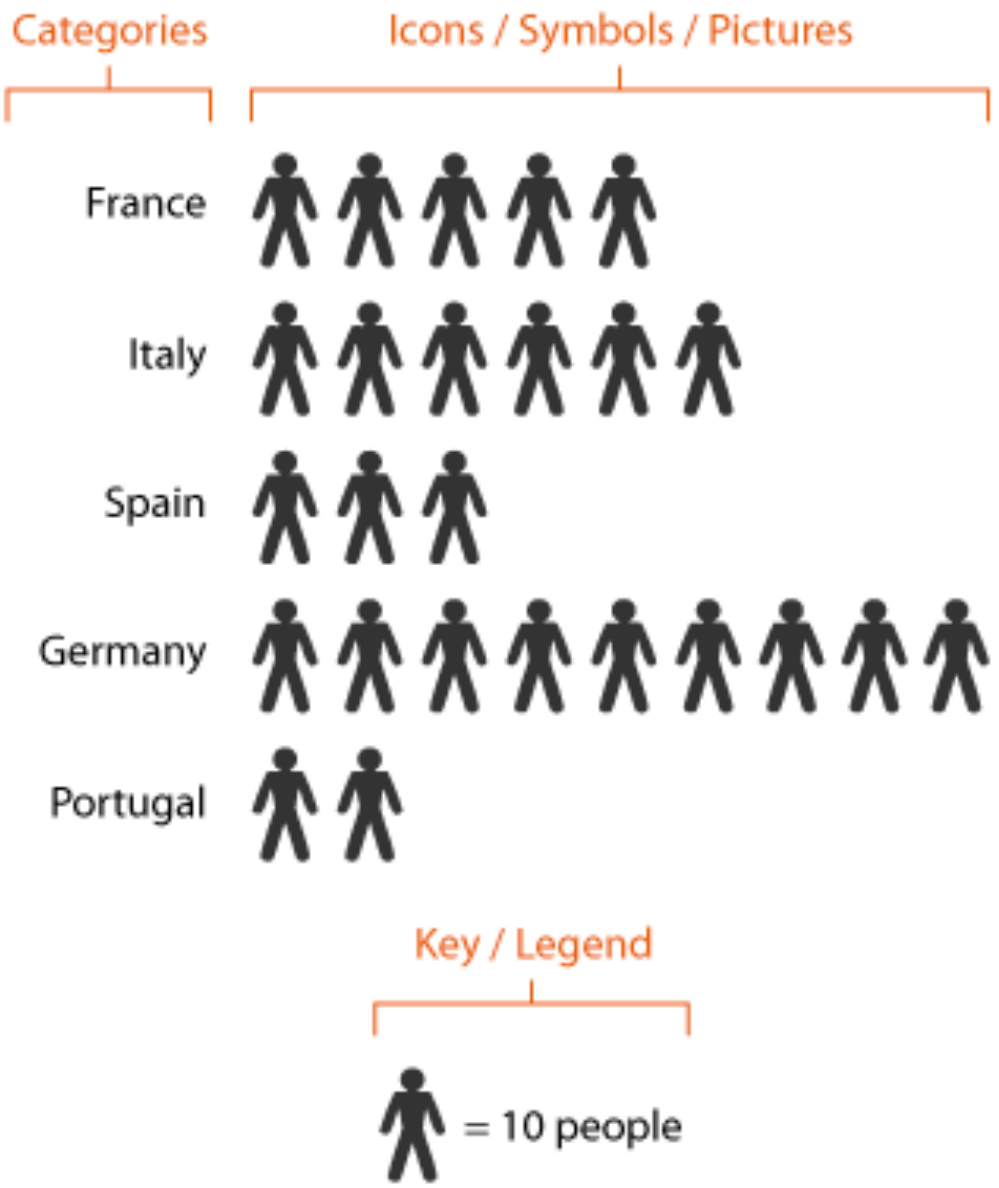
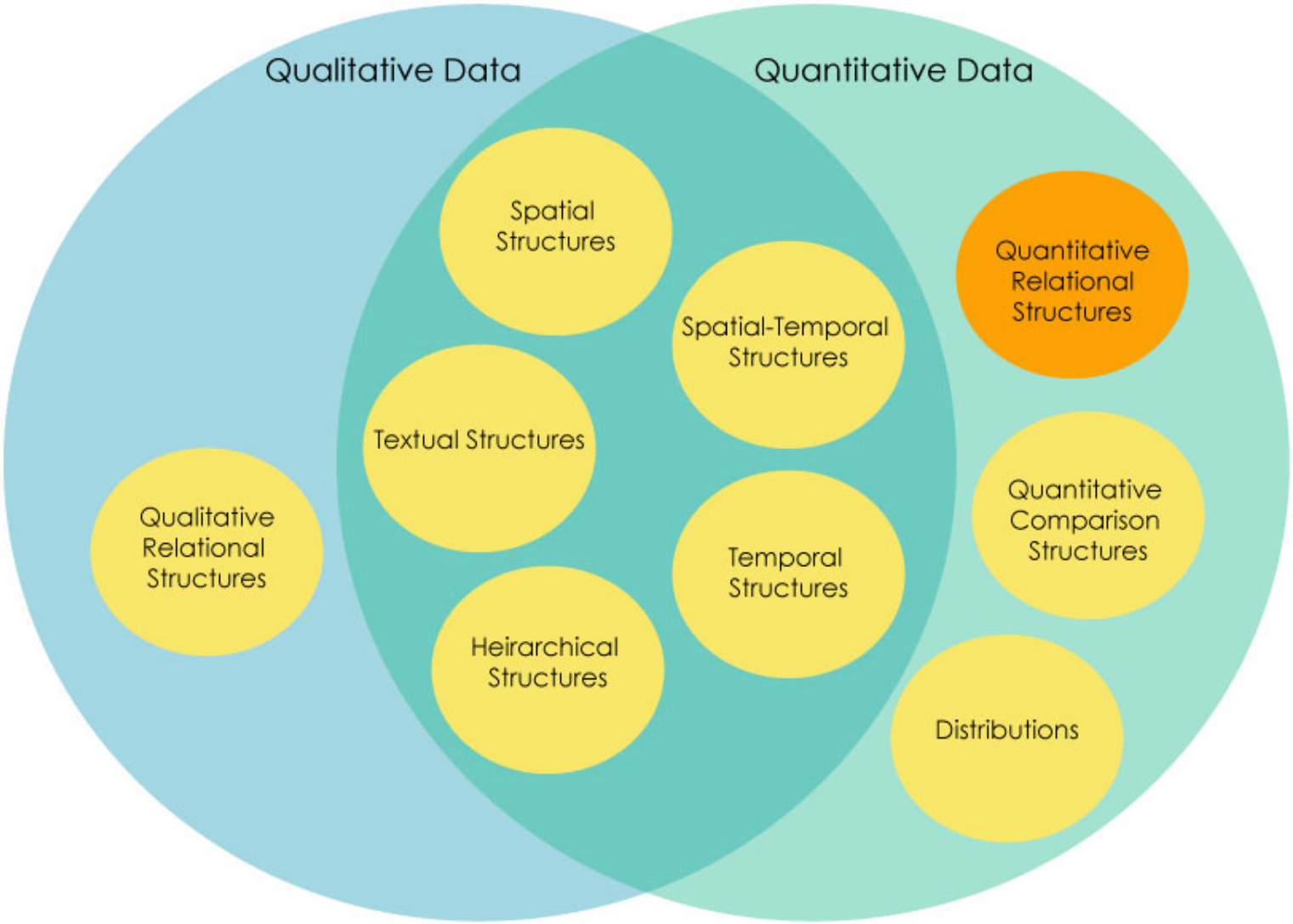


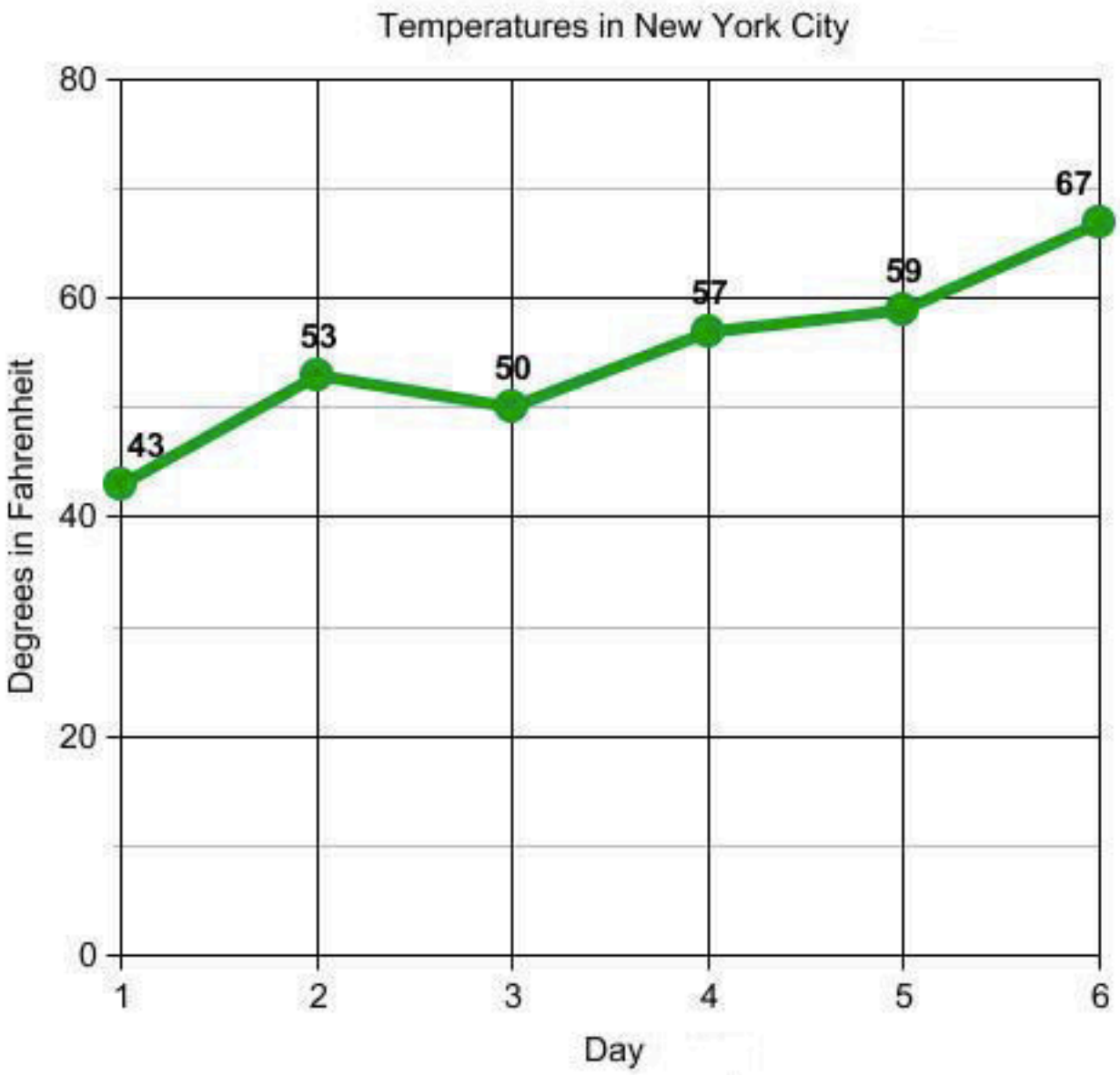
Image Source: http://www.datavizcatalogue.com/methods/pictogram.html#.Vk0RGt-rSRs


Qualitative Data
Quantitative Data
Spatial Structures
Spatial-Temporal Structures
Quantitative Relational Structures
Textual Structures
Qualitative Relational Structures
Quantitative Comparison Structures
Temporal Structures
Heirarchical Structures
Distributions

Quantitative Relational

Line Charts

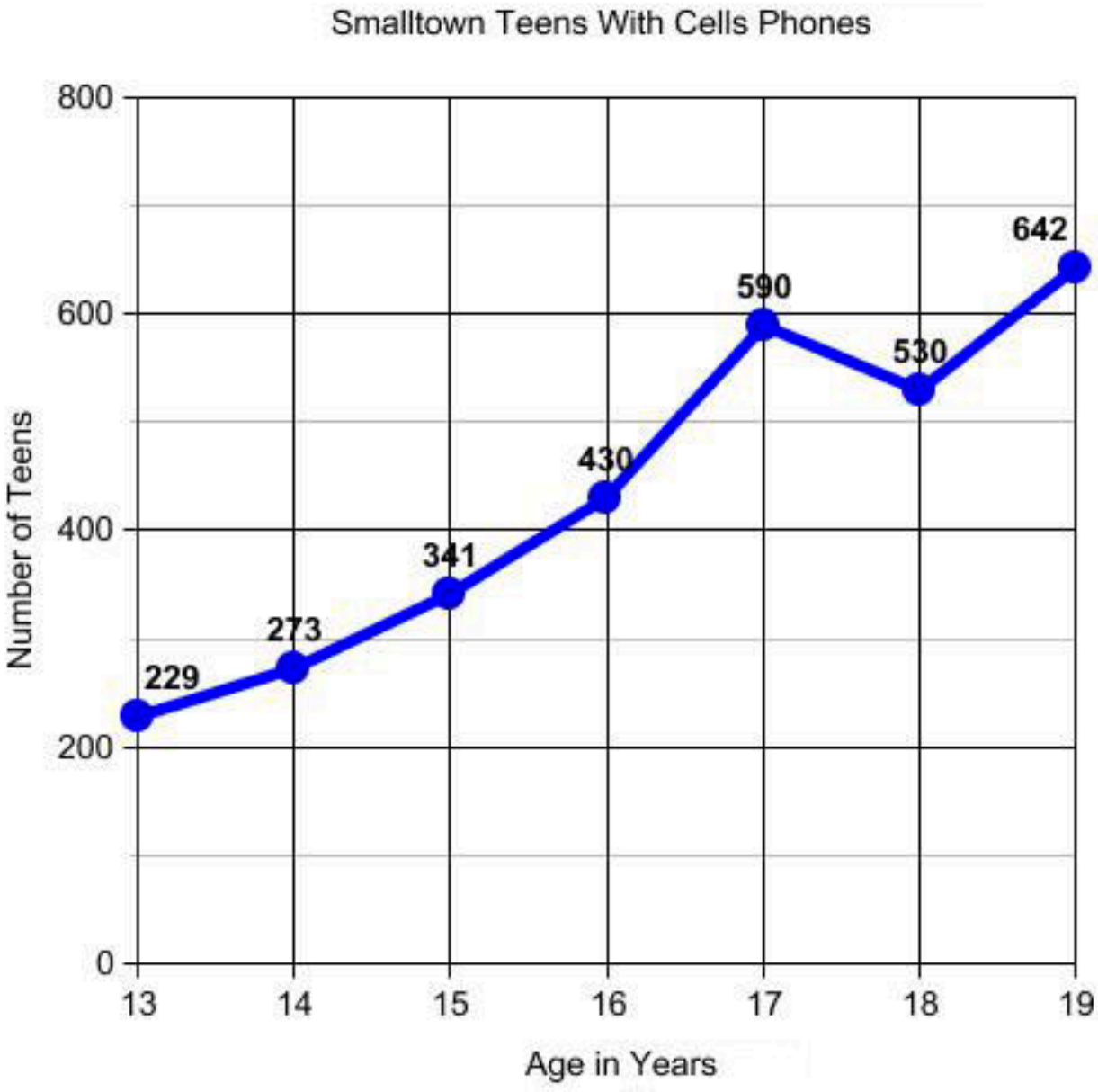
For identifying trends.



Quantitative Relational

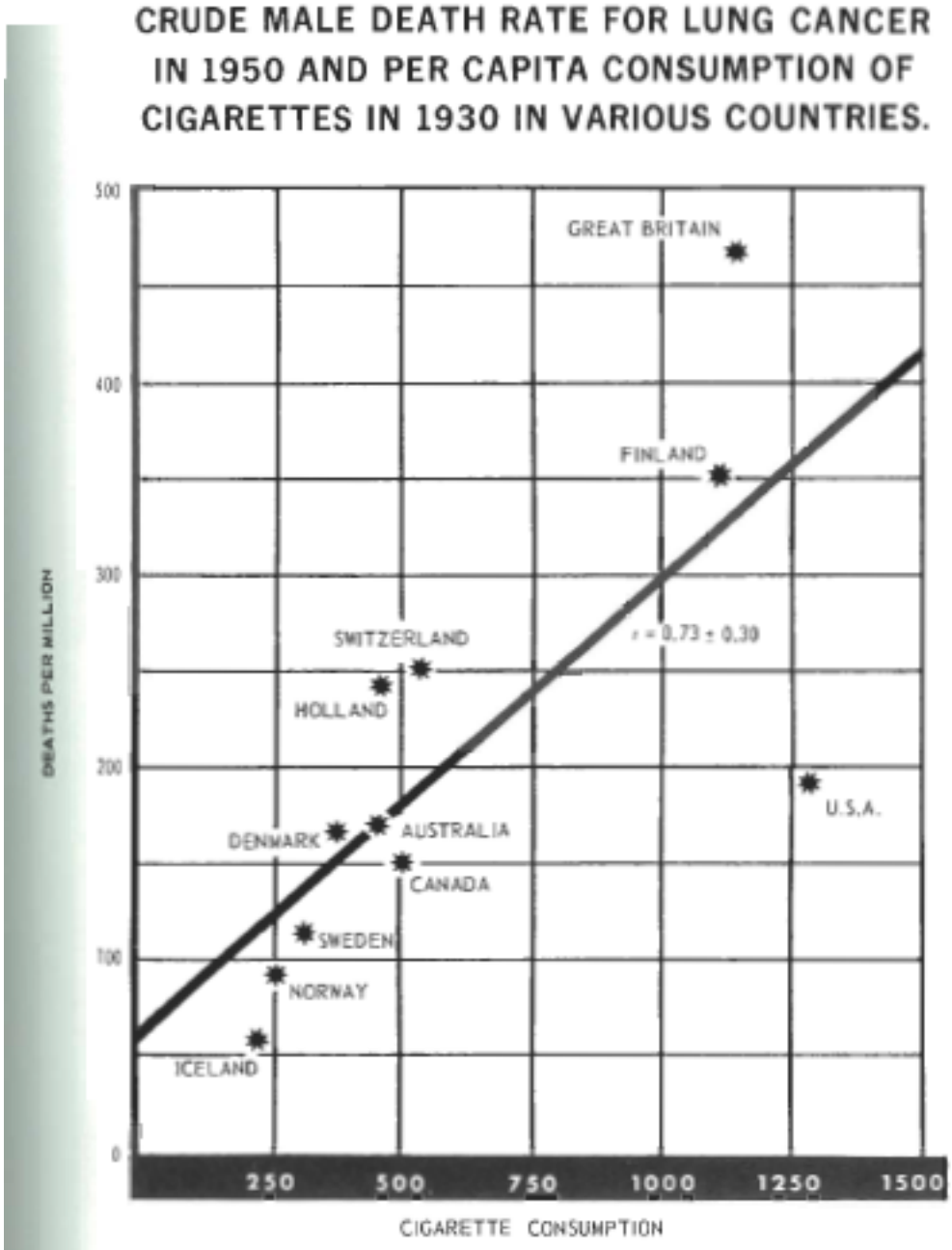
Line Charts

For identifying trends.



Scatter Plots

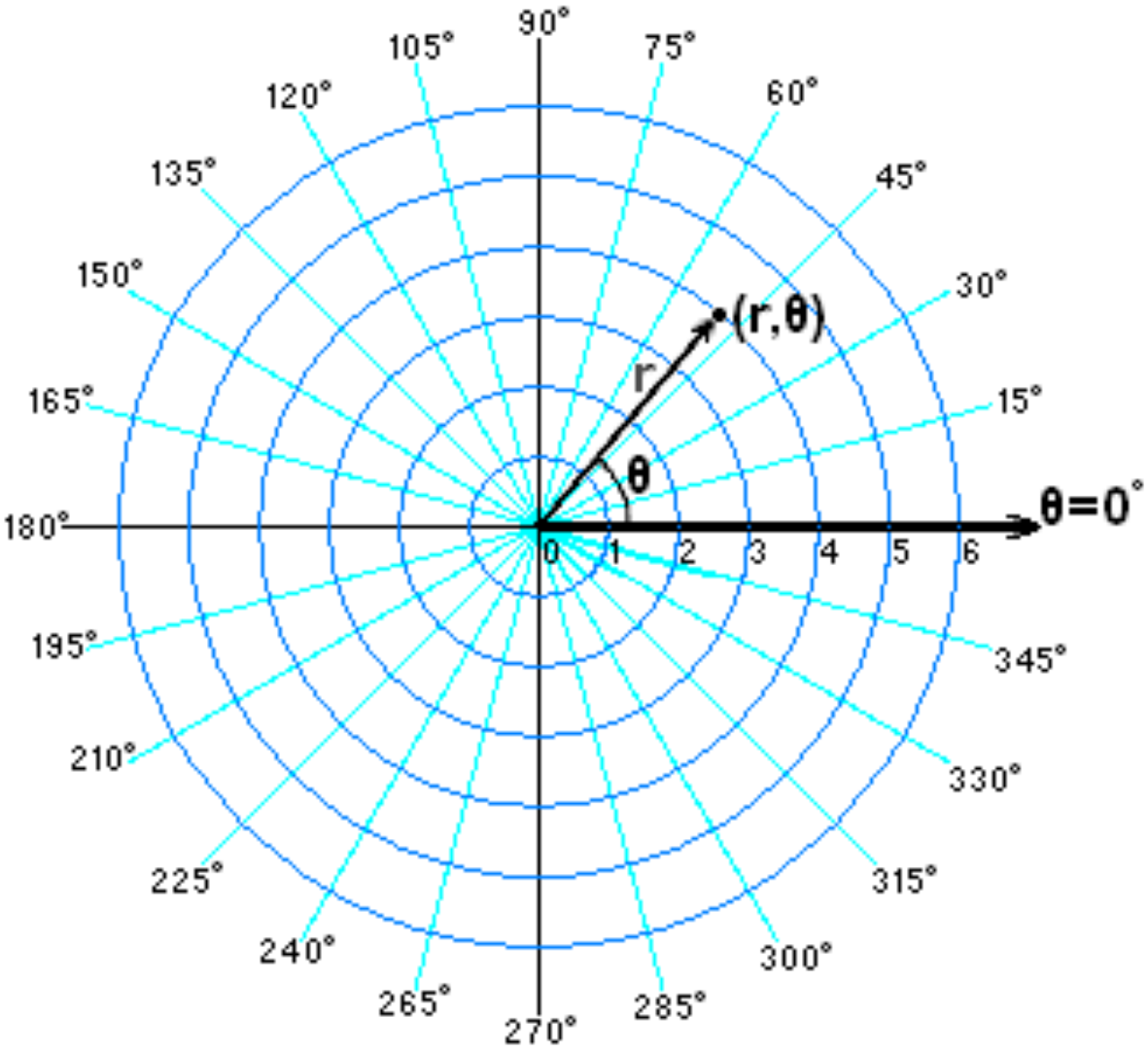
For testing and identifying relationships, and statistical correlations



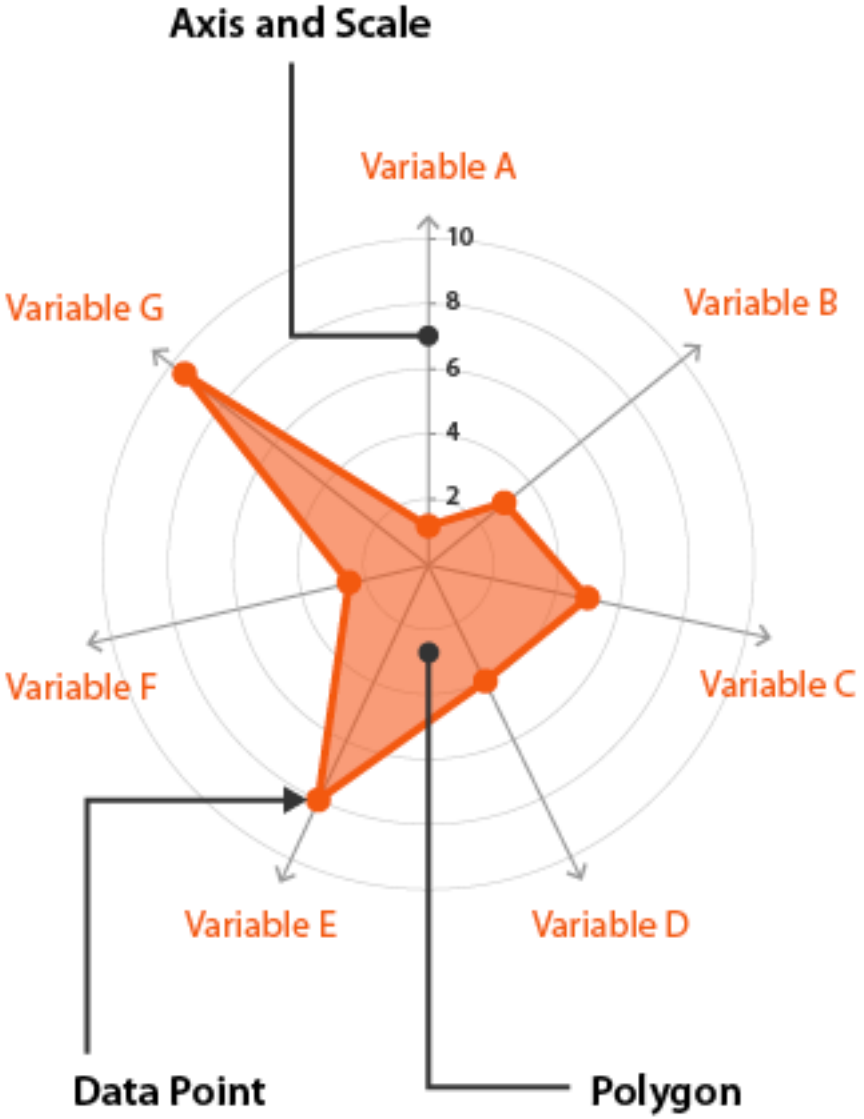
Report of the Advisory Committee to the Surgeon General, *Smoking and Health* (Washington, D.C., 1964), p. 176; based on R. Doll, "Etiology of Lung Cancer," *Advances in Cancer Research*, 3 (1955), 1–50.

Polar Coordinates

Another way to describe the plane:
Instead of (x, y),
Use (r, θ)



Radar Charts



Quantitative Relational

Surface plots

Topography, Density
Functions that have two dependent variables

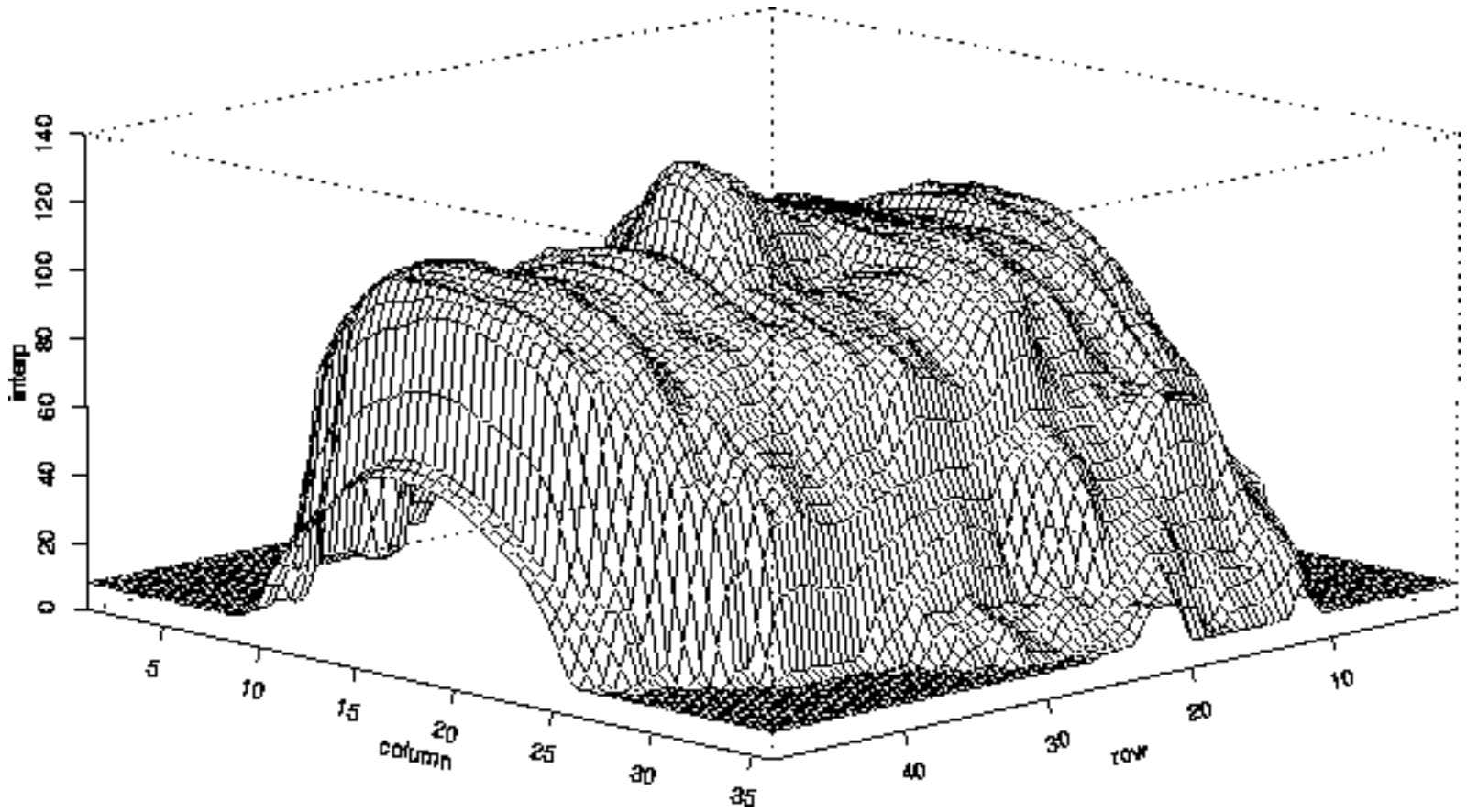
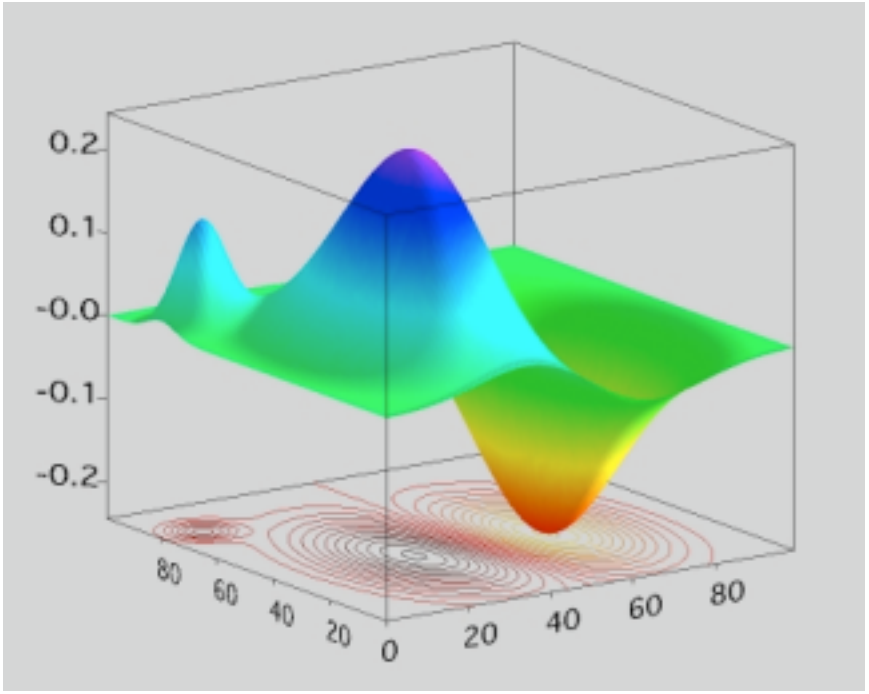


Image Source:
http://ceadserv1.nku.edu/longa//confs/miami/

Quantitative Relational

Surface plots

Topography, Density
Functions that have two dependent variables



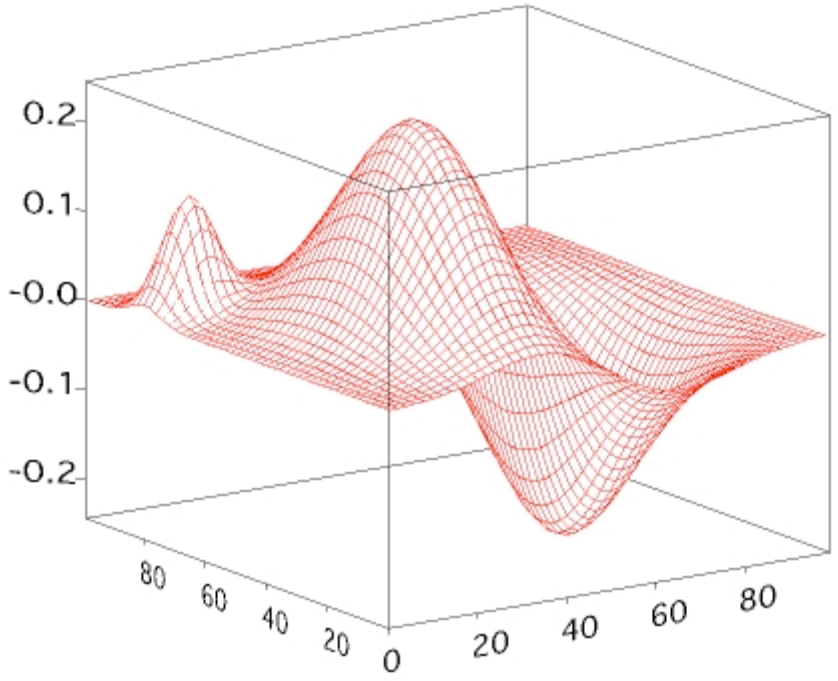
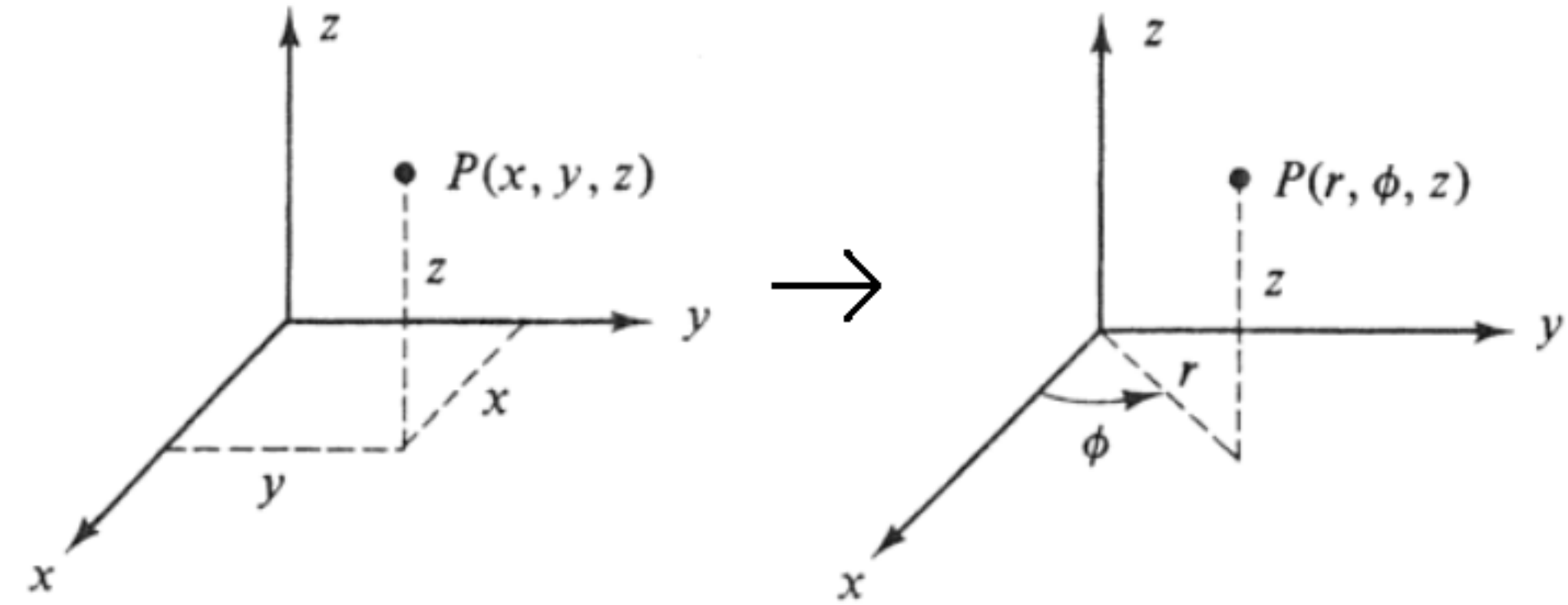


Image Source:
https://www.wavemetrics.com/products/igorpro/creatinggraphs/3dandvolume/surface.htm

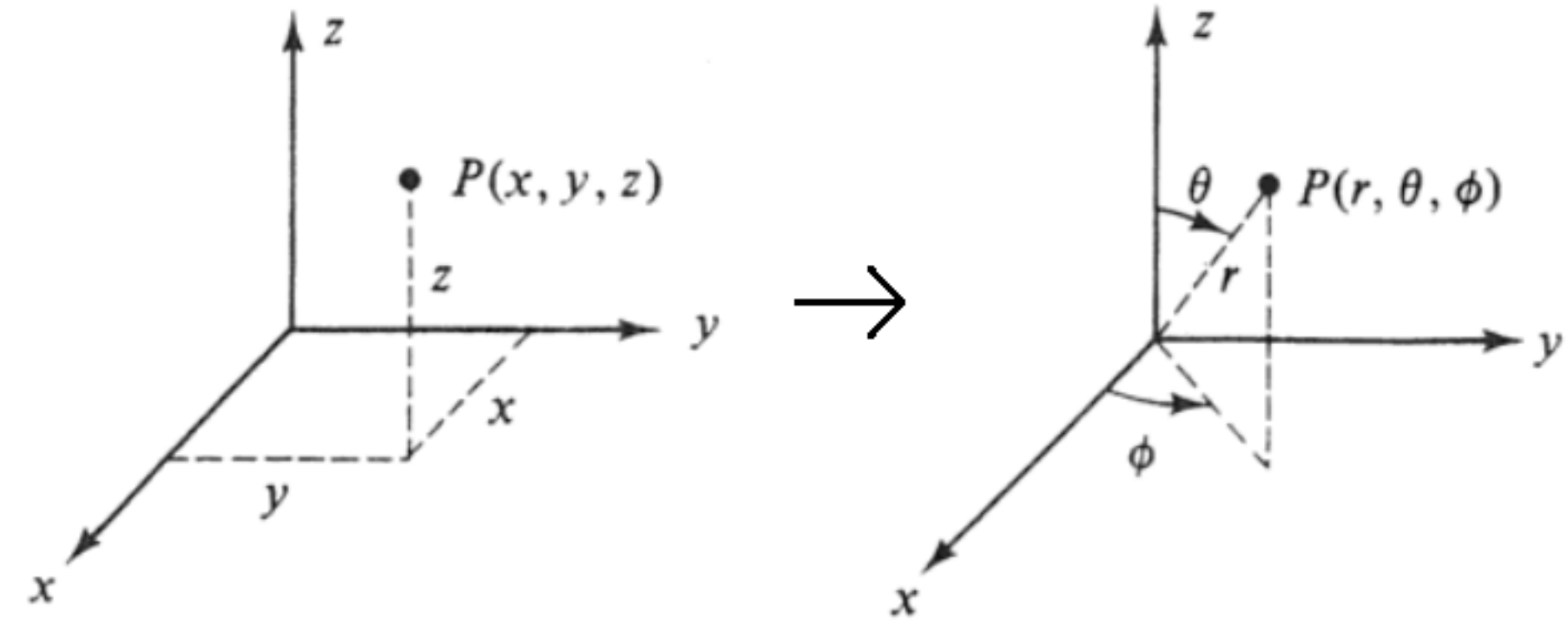
Cylindrical Coordinates

Another way to describe the plane:
Instead of (x, y, z),
Use (r, ϕ, z)



Spherical Coordinates

Another way to describe the plane:
Instead of (x, y, z),
Use (r, ϕ, θ)



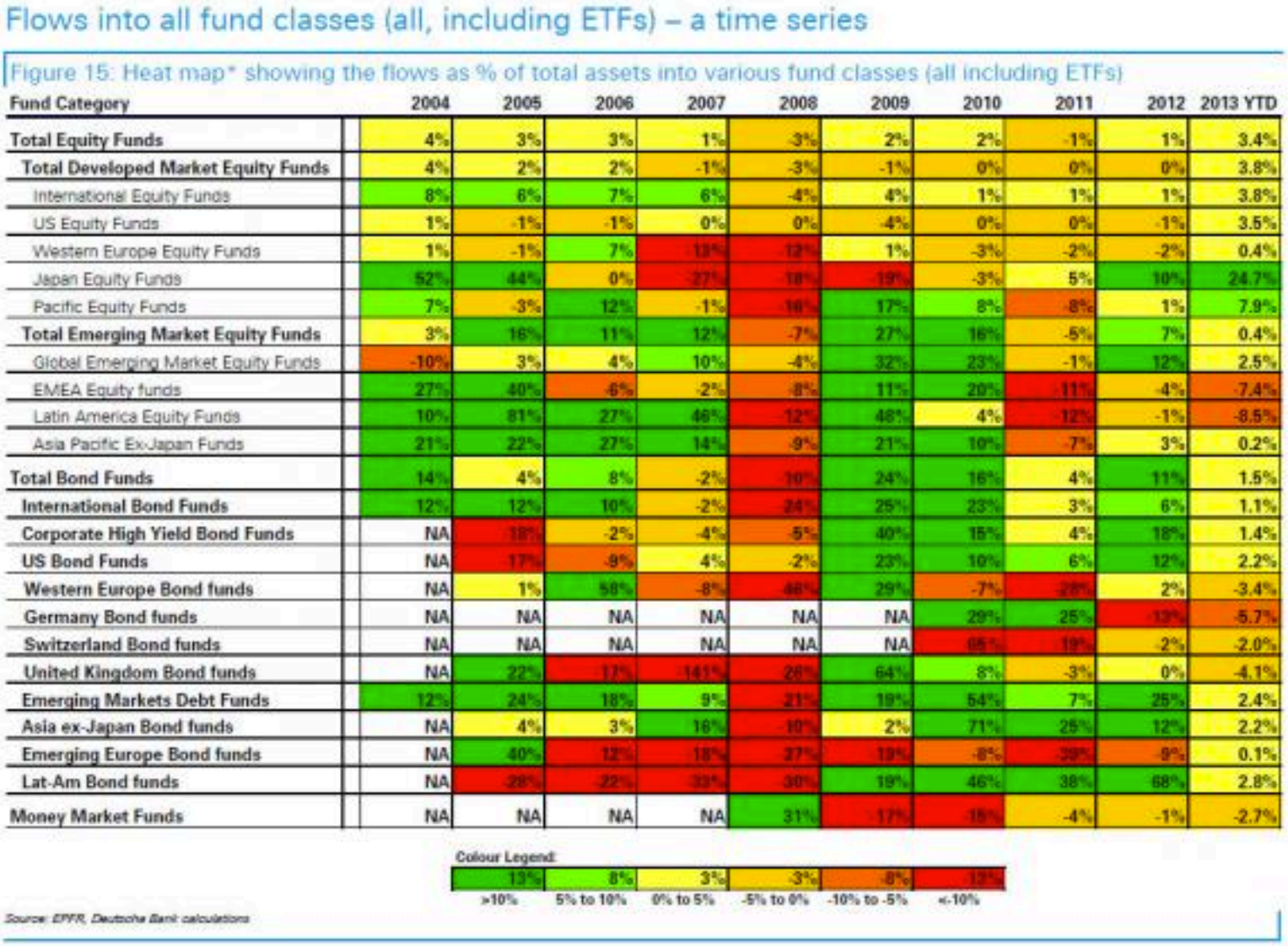
Quantitative Relational

Heat map

Image Source:
http://blog.monitor.us/2012/08/best-website-optimization-tools/

Quantitative Relational

Heat map/ Co-occurrence matrix



Flows into all fund classes (all, including ETFs) – a time series

Figure 15: Heat map* showing the flows as % of total assets into various fund classes (all including ETFs)

Fund Category	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013 YTD
Total Equity Funds	4%	3%	3%	1%	-3%	2%	2%	-1%	1%	3.4%
Total Developed Market Equity Funds	4%	2%	2%	-1%	-3%	-1%	0%	0%	0%	3.8%
International Equity Funds	8%	6%	7%	6%	-4%	4%	1%	1%	1%	3.8%
US Equity Funds	1%	-1%	-1%	0%	0%	-4%	0%	0%	-1%	3.5%
Western Europe Equity Funds	1%	-1%	7%	13%	-12%	1%	-3%	-2%	-2%	0.4%
Japan Equity Funds	52%	44%	0%	-27%	-18%	-19%	-3%	5%	10%	24.7%
Pacific Equity Funds	7%	-3%	12%	-1%	-16%	17%	8%	-8%	1%	7.9%
Total Emerging Market Equity Funds	3%	16%	11%	12%	-7%	27%	16%	-5%	7%	0.4%
Global Emerging Market Equity Funds	-10%	3%	4%	10%	-4%	32%	23%	-1%	12%	2.5%
EMEA Equity funds	27%	40%	-6%	-2%	-8%	11%	20%	-11%	-4%	-7.4%
Latin America Equity Funds	10%	81%	27%	46%	-12%	48%	4%	-12%	-1%	-8.5%
Asia Pacific Ex-Japan Funds	21%	22%	27%	14%	-9%	21%	10%	-7%	3%	0.2%
Total Bond Funds	14%	4%	8%	-2%	-10%	24%	16%	4%	11%	1.5%
International Bond Funds	12%	12%	10%	-2%	-24%	25%	23%	3%	6%	1.1%
Corporate High Yield Bond Funds	NA	-18%	-2%	-4%	-5%	40%	15%	4%	18%	1.4%
US Bond Funds	NA	-17%	-9%	4%	-2%	23%	10%	6%	12%	2.2%
Western Europe Bond funds	NA	1%	58%	-8%	-46%	29%	-7%	-28%	2%	-3.4%
Germany Bond funds	NA	NA	NA	NA	NA	NA	29%	25%	-13%	-5.7%
Switzerland Bond funds	NA	NA	NA	NA	NA	NA	-65%	19%	-2%	-2.0%
United Kingdom Bond funds	NA	22%	-17%	-141%	-26%	64%	8%	-3%	0%	-4.1%
Emerging Markets Debt Funds	12%	24%	18%	9%	-21%	19%	54%	7%	25%	2.4%
Asia ex-Japan Bond funds	NA	4%	3%	16%	-10%	2%	71%	25%	12%	2.2%
Emerging Europe Bond funds	NA	40%	-12%	-18%	-27%	-19%	-8%	-39%	-9%	0.1%
Lat-Am Bond funds	NA	-28%	-22%	-33%	-30%	19%	46%	38%	68%	2.8%
Money Market Funds	NA	NA	NA	NA	31%	-17%	-15%	-4%	-1%	-2.7%

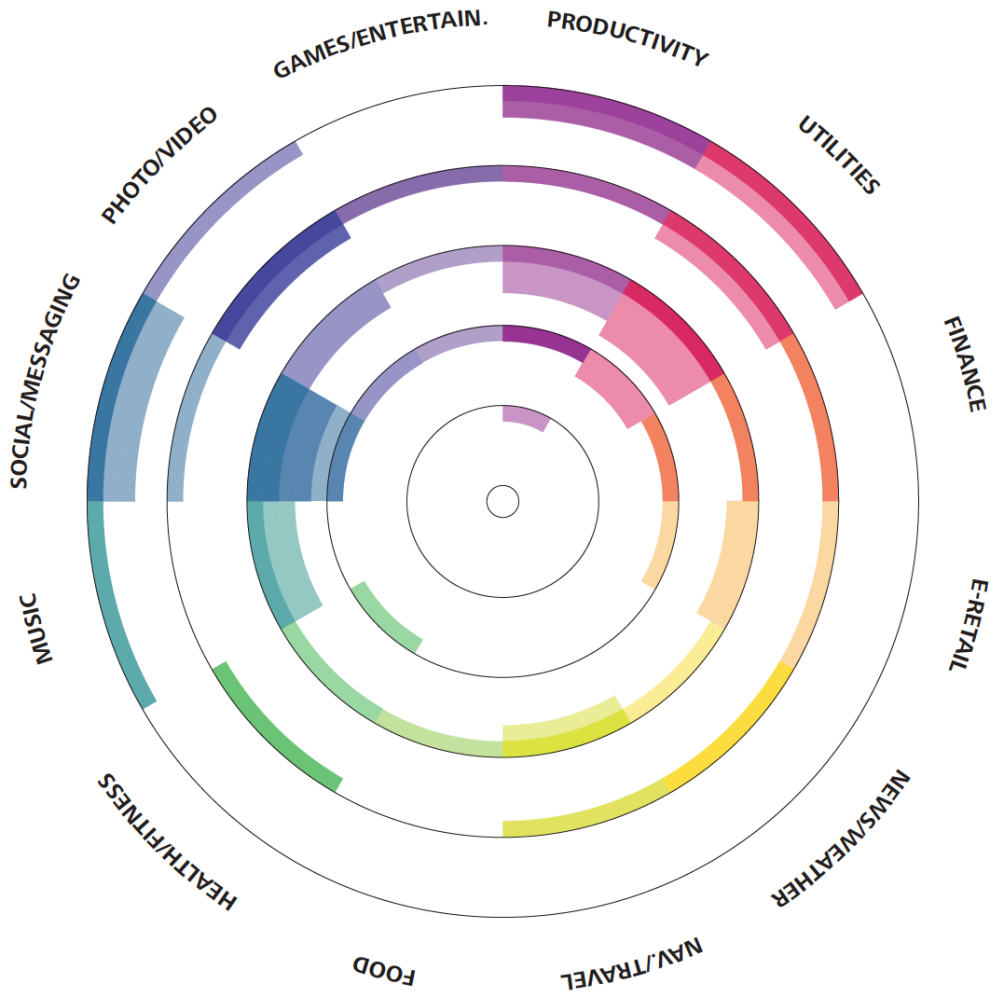
Colour Legend:

>10%	5% to 10%	0% to 5%	-5% to 0%	-10% to -5%	<-10%
13%	8%	3%	-3%	-8%	-13%

Source: EPFR, Deutsche Bank calculations

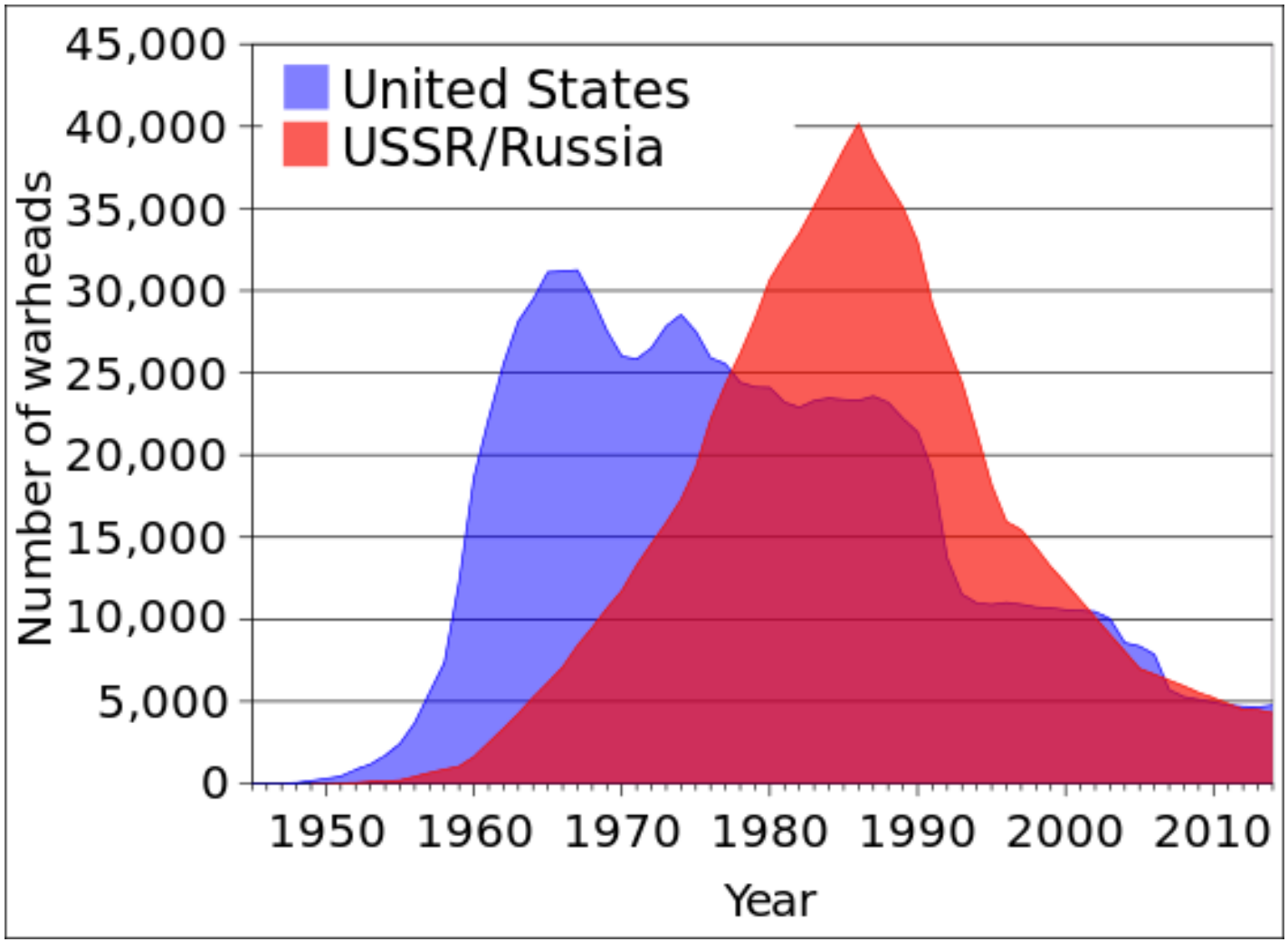
Image Source:
http://www.zerohedge.com/news/2013-08-09/definitive-fund-flows-heatmap-10-years-capital-flows

Heat map/ Co-occurrence matrix in **cylindrical coordinates**



Quantitative Relational and Comparison

Area Graph



"US and USSR nuclear stockpiles" by Created by User:Fastfission first by mapping the lines using OpenOffice.org's Calc program, then exporting a graph to SVG, and the performing substantial aesthetic modifications in Inkscape. - Own work Source data from: Robert S. Norris and Hans M. Kristensen, "Global nuclear stockpiles, 1945-2006," Bulletin of the Atomic Scientists 62, no. 4 (July/August 2006), 64-66. Online at http://thebulletin.metapress.com/content/c4120650912x74k7/fulltext.pdf. Licensed under Public Domain via Commons - https://commons.wikimedia.org/wiki/File:US_and_USSR_nuclear_stockpiles.svg#/media/File:US_and_USSR_nuclear_stockpiles.svg

Quantitative Relational and Comparison

Stacked Area Graph

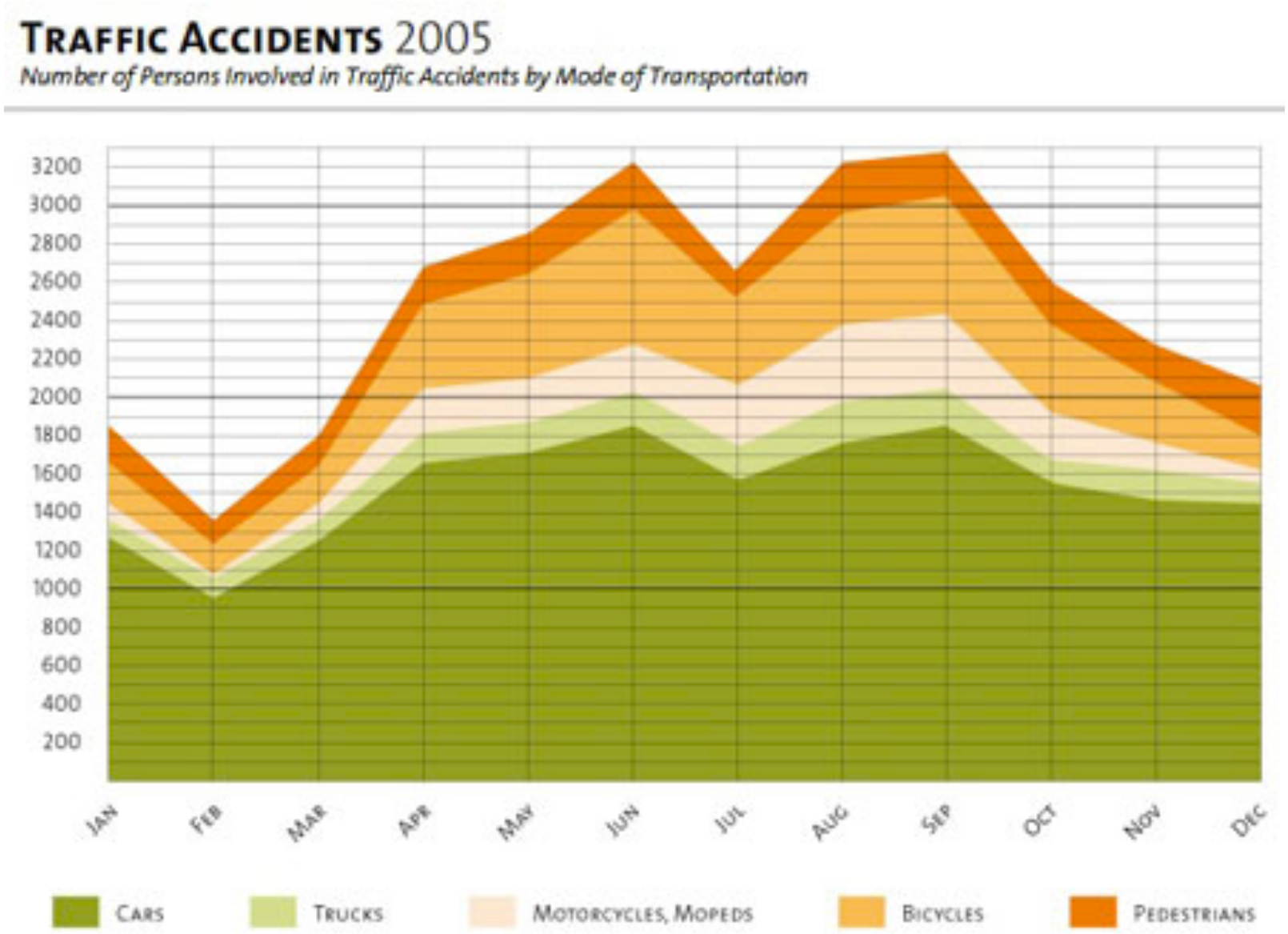
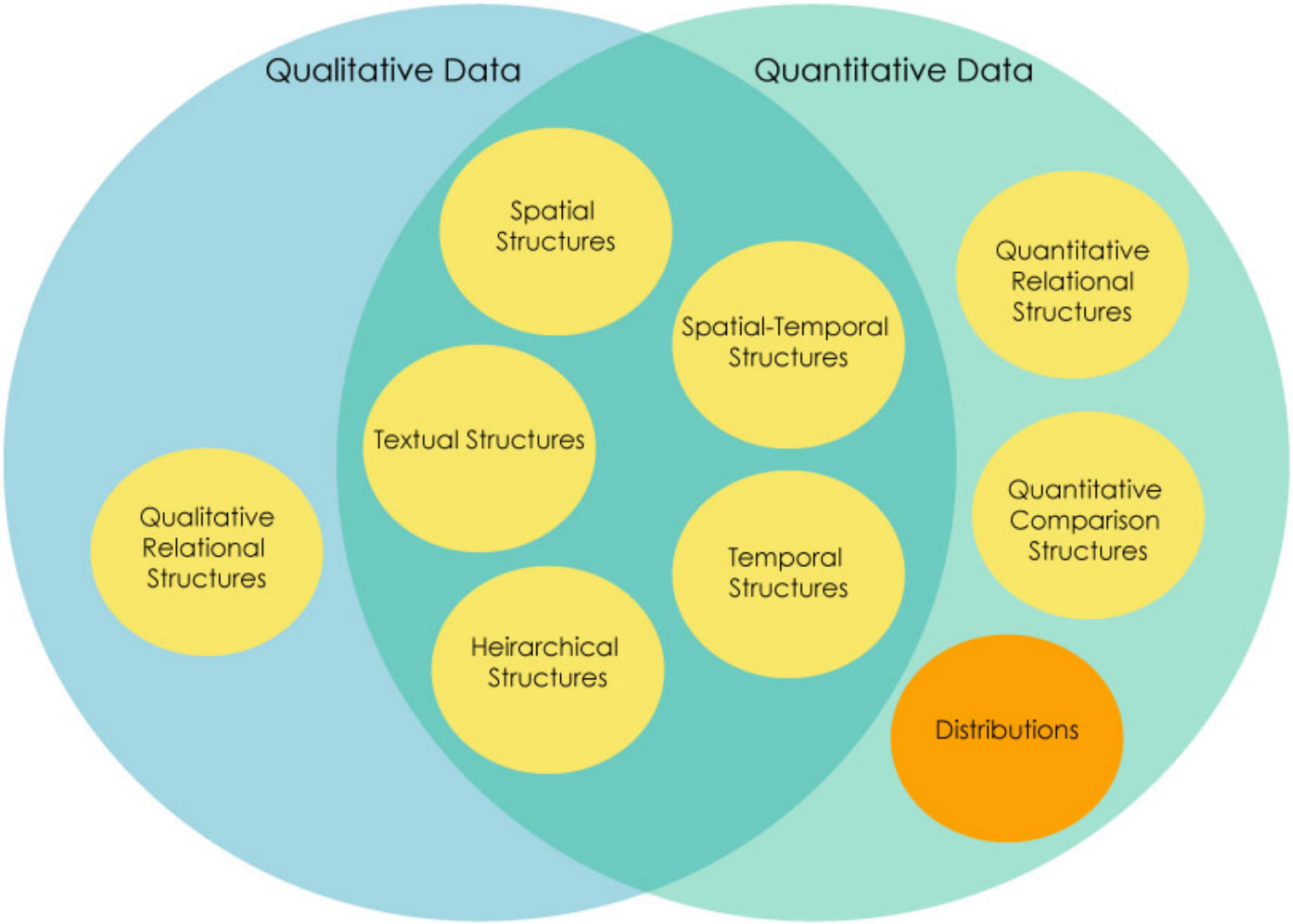
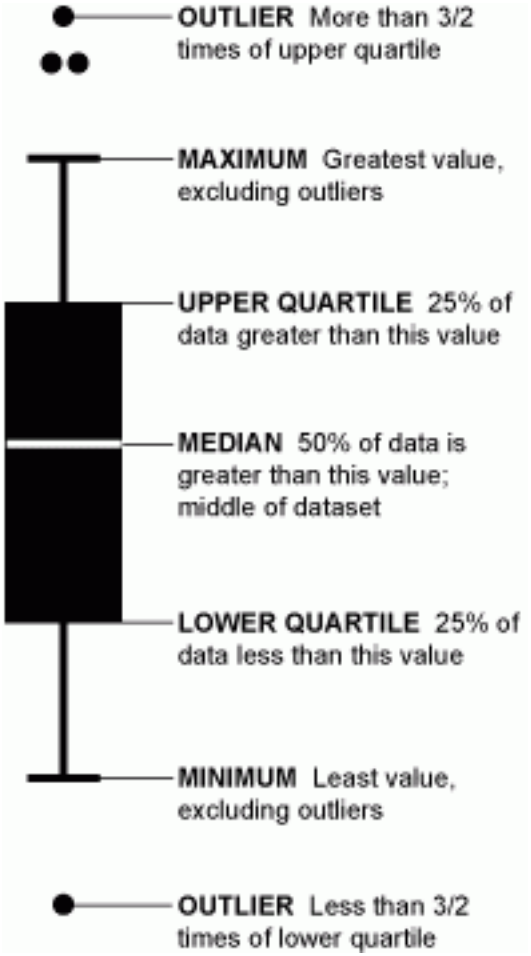


Image Source: http://www.mrpalsmy.com/?p=1389


Qualitative Data
Quantitative Data
Spatial Structures
Spatial-Temporal Structures
Quantitative Relational Structures
Textual Structures
Quantitative Comparison Structures
Qualitative Relational Structures
Temporal Structures
Heirarchical Structures
Distributions

Box and Whisker Plot



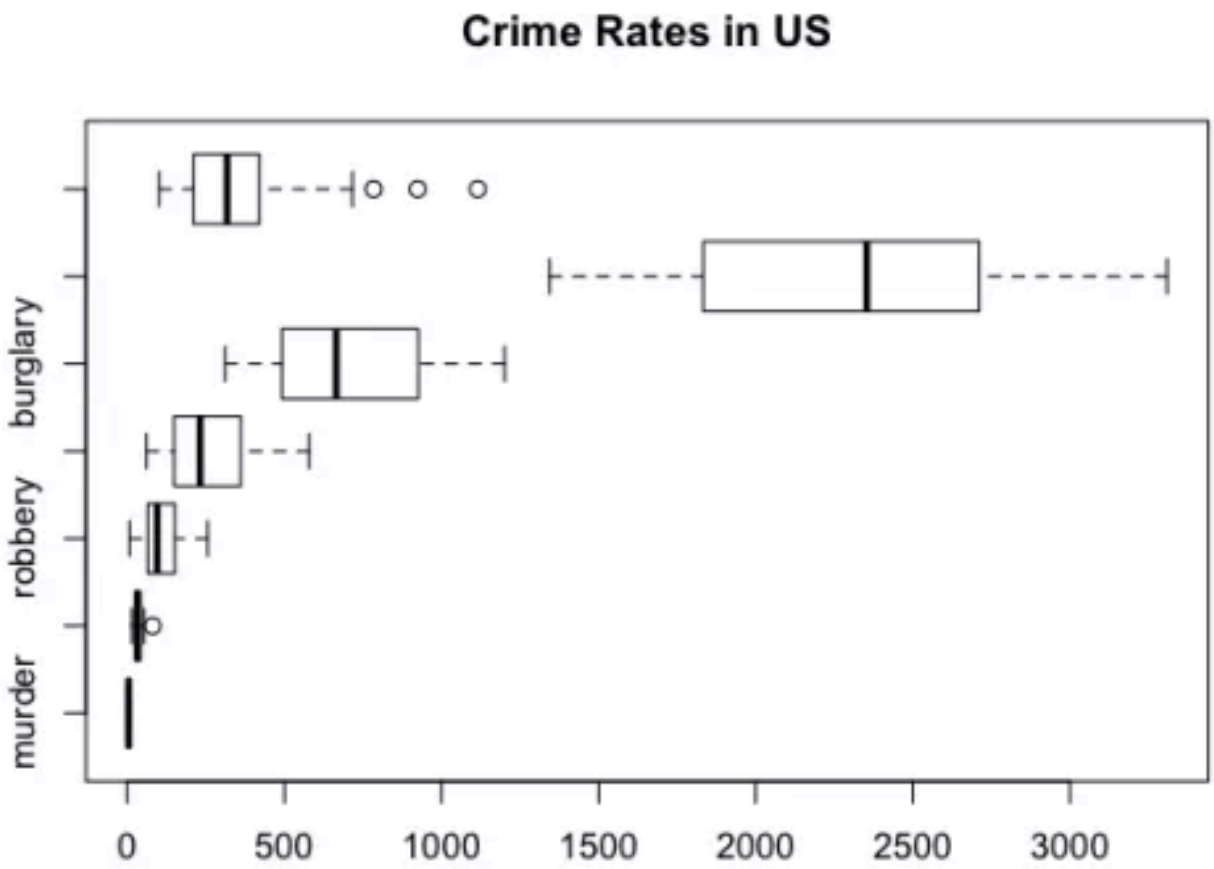


Image Source: https://flowingdata.com/2012/05/15/how-to-visualize-and-compare-distributions/

Distributions

Histograms

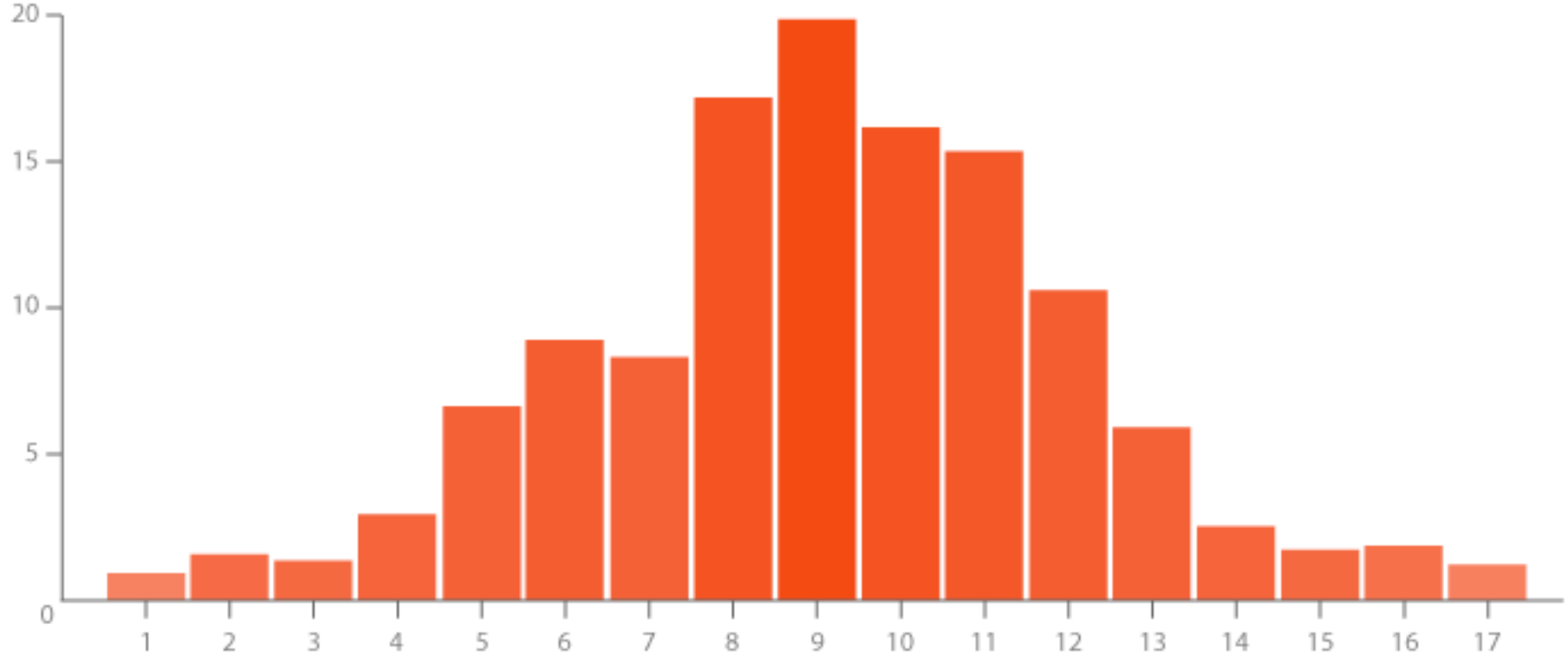


Image Source: http://www.datavizcatalogue.com/methods/histogram.html

Distributions

Histograms

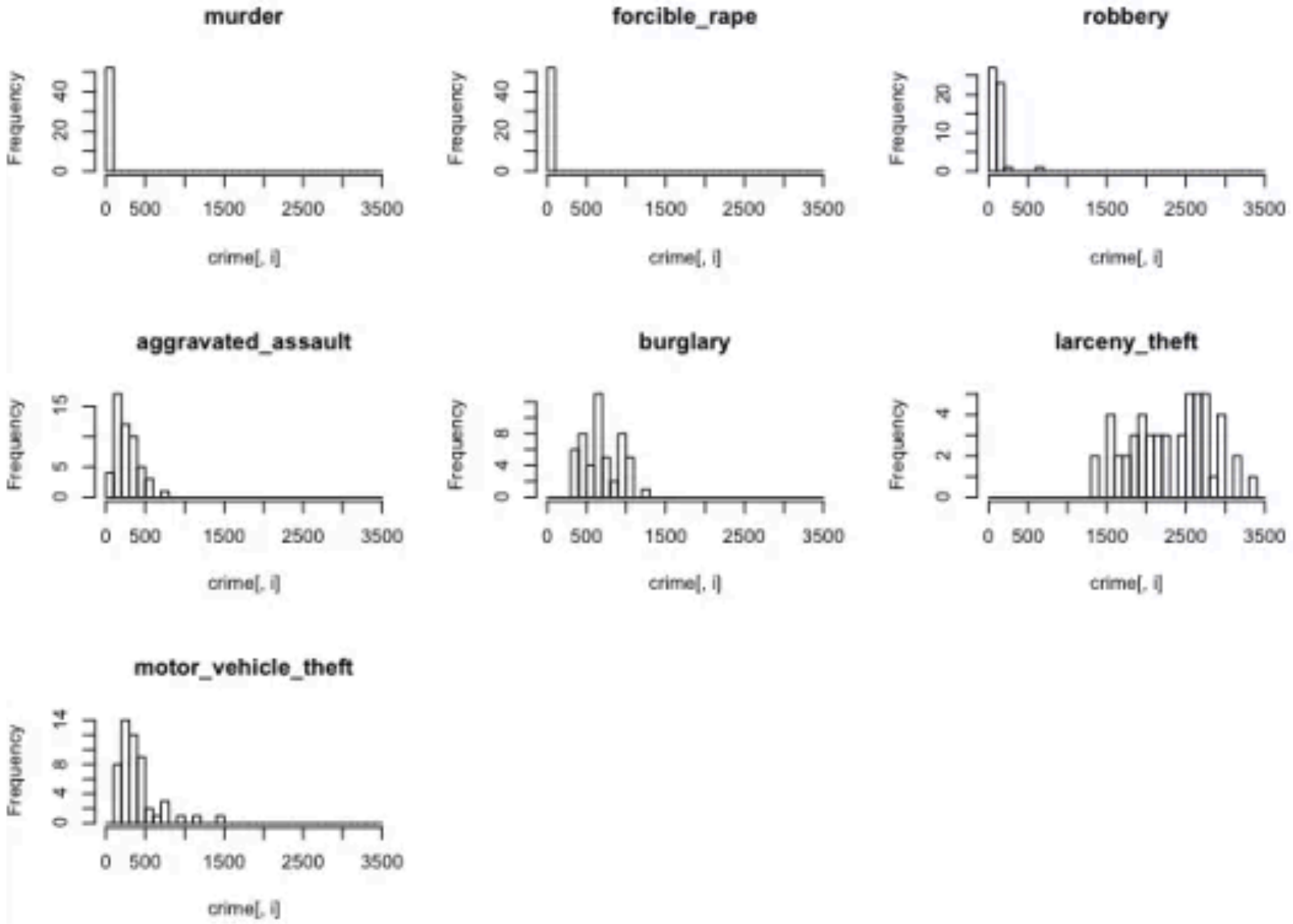
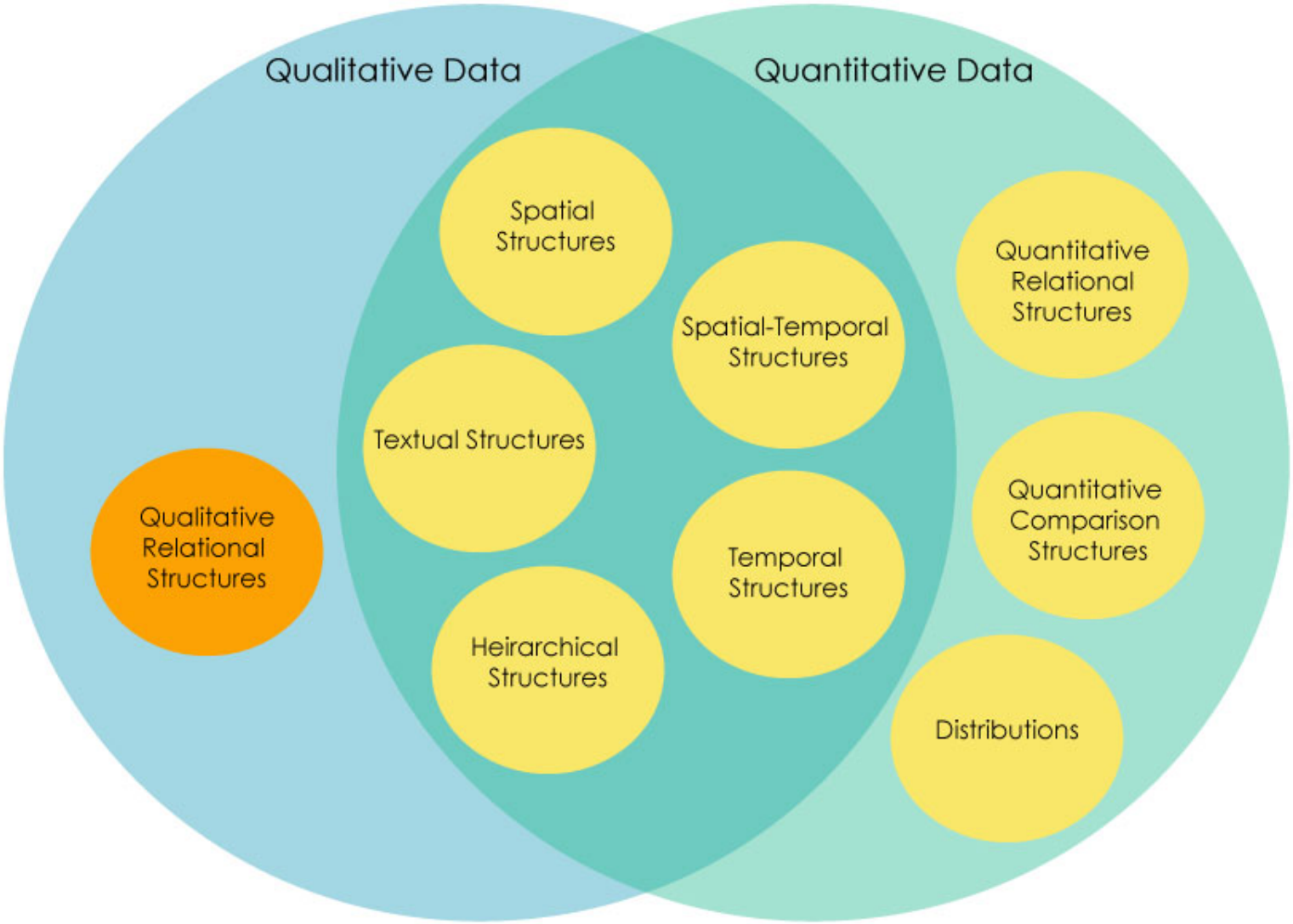


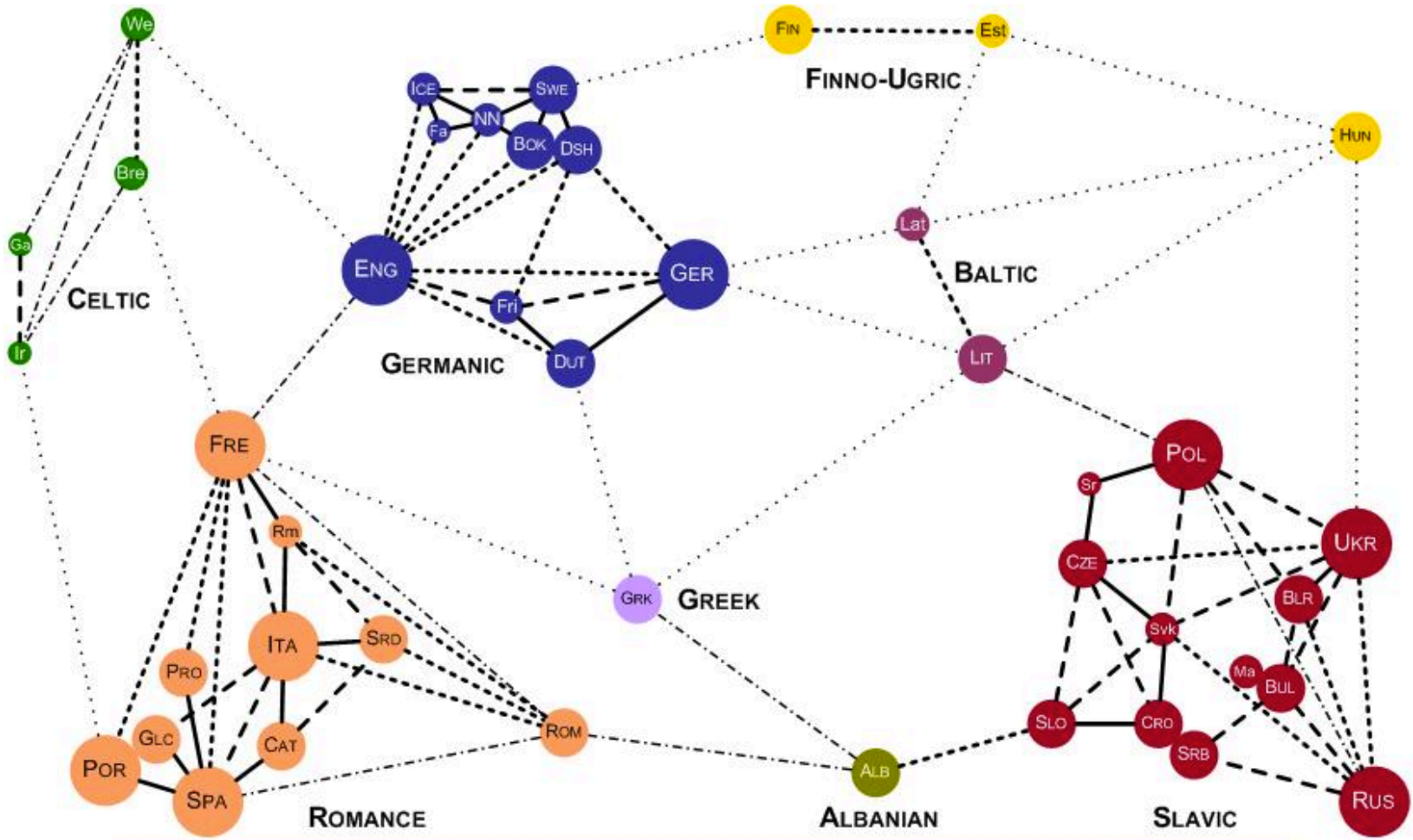
Image Source: https://flowingdata.com/2012/05/15/how-to-visualize-and-compare-distributions/


Qualitative Data
Quantitative Data
Spatial Structures
Spatial-Temporal Structures
Quantitative Relational Structures
Textual Structures
Quantitative Comparison Structures
Qualitative Relational Structures
Temporal Structures
Heirarchical Structures
Distributions

Qualitative Relational Structures

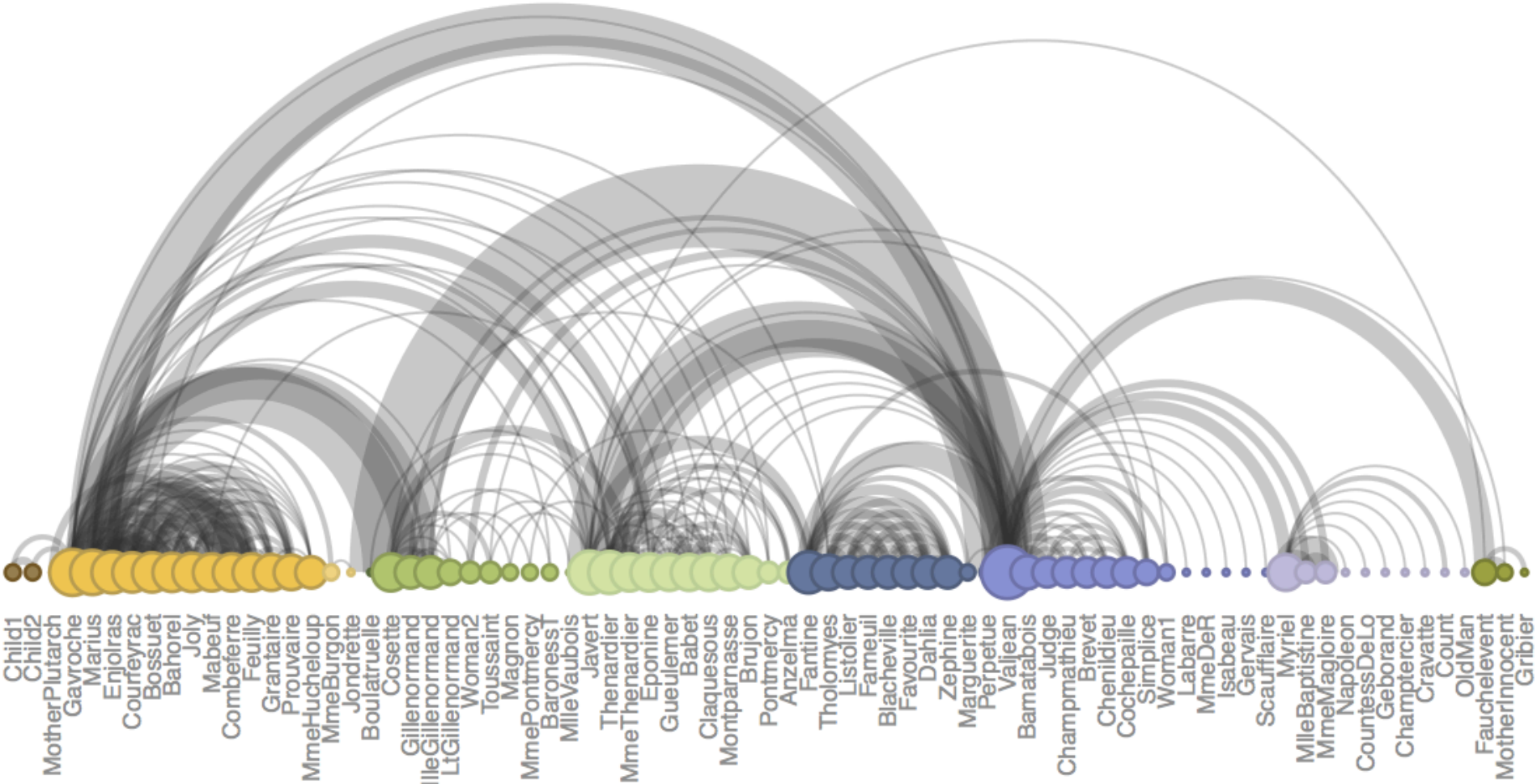
Networks

Force-directed node-link diagram



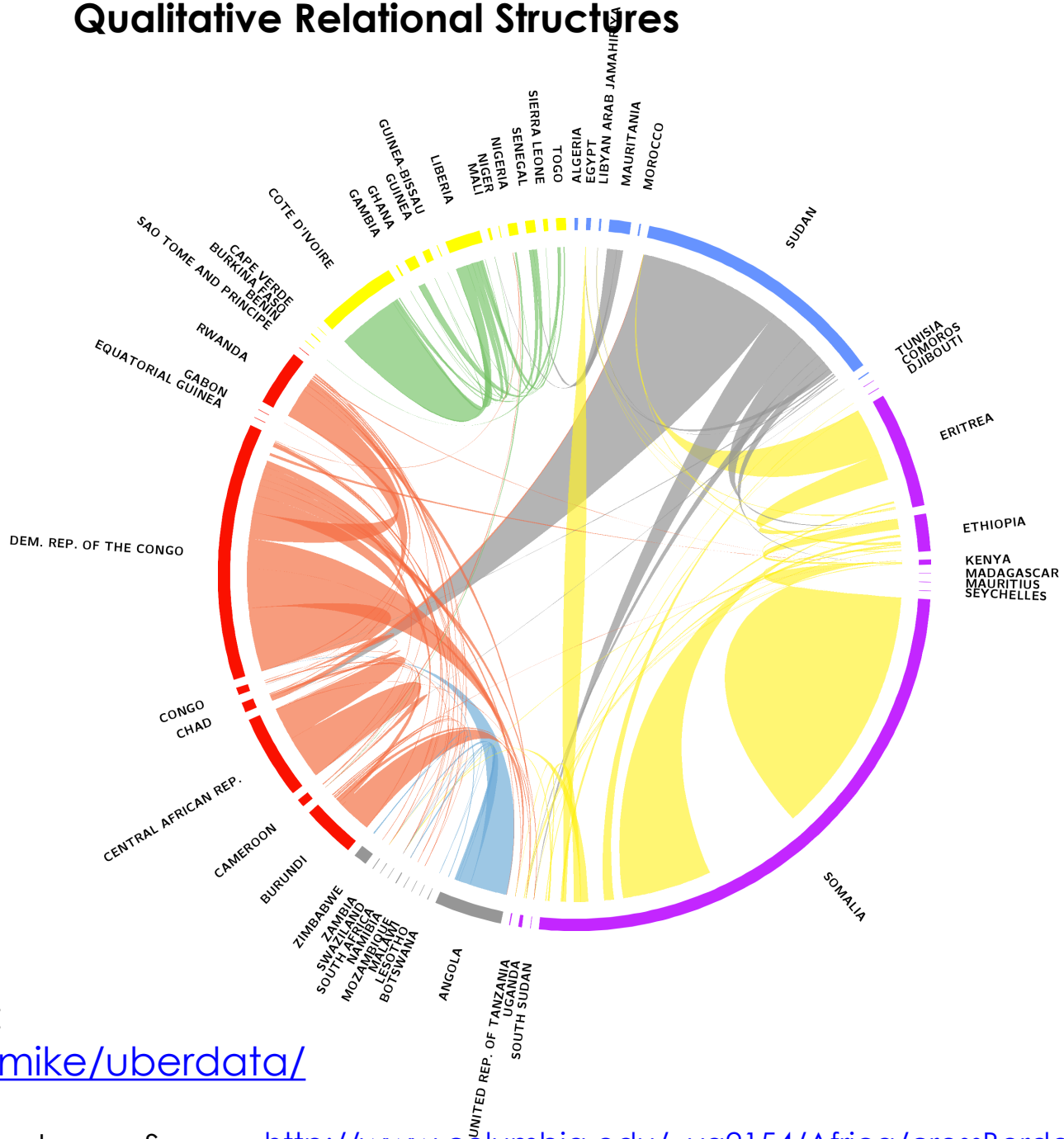
Networks

Linear Layout



Networks

Chord Diagram



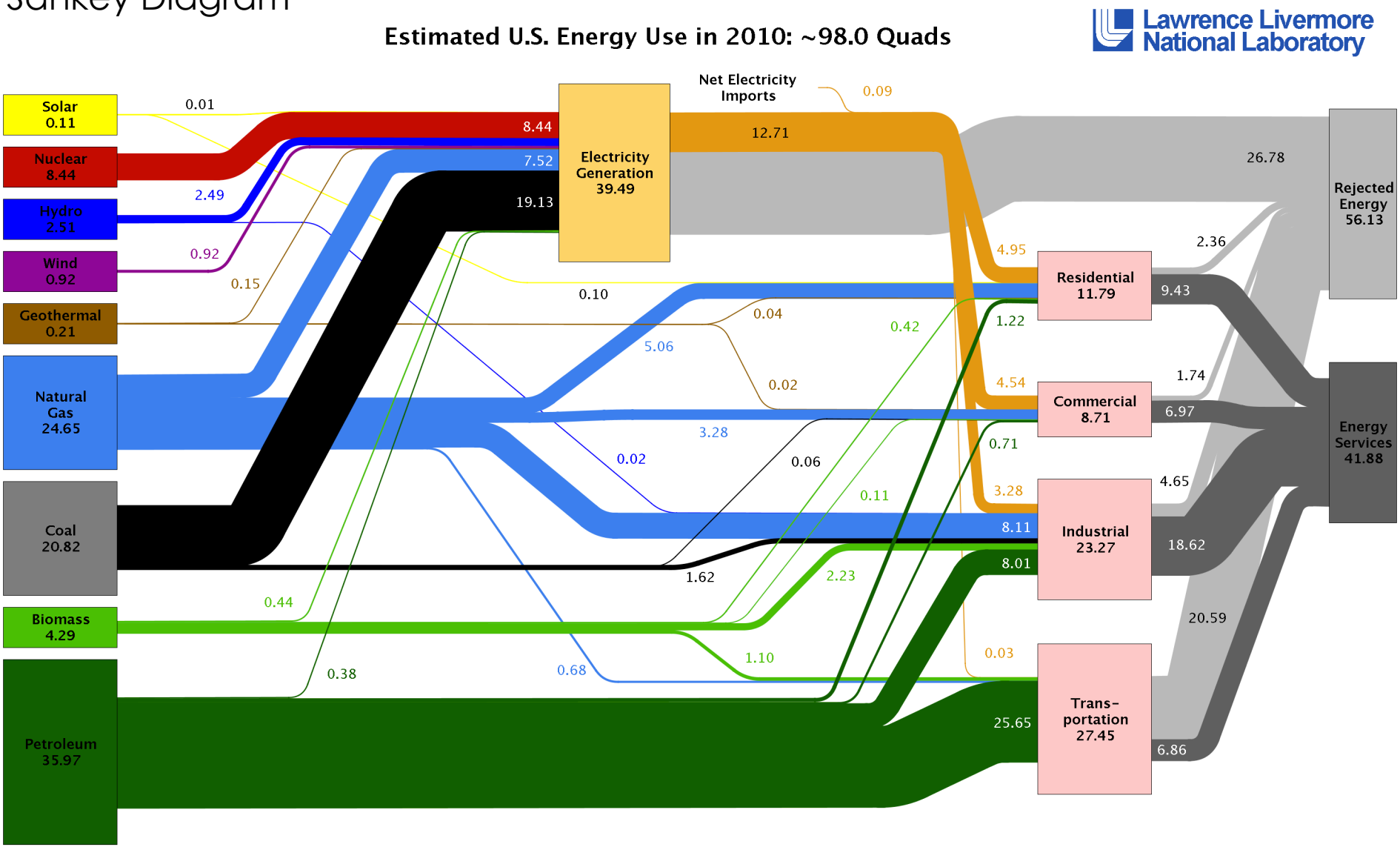
Interactive example:
http://bost.ocks.org/mike/uberdata/

Image Source: http://www.columbia.edu/~yq2154/Africa/crossBorder.html

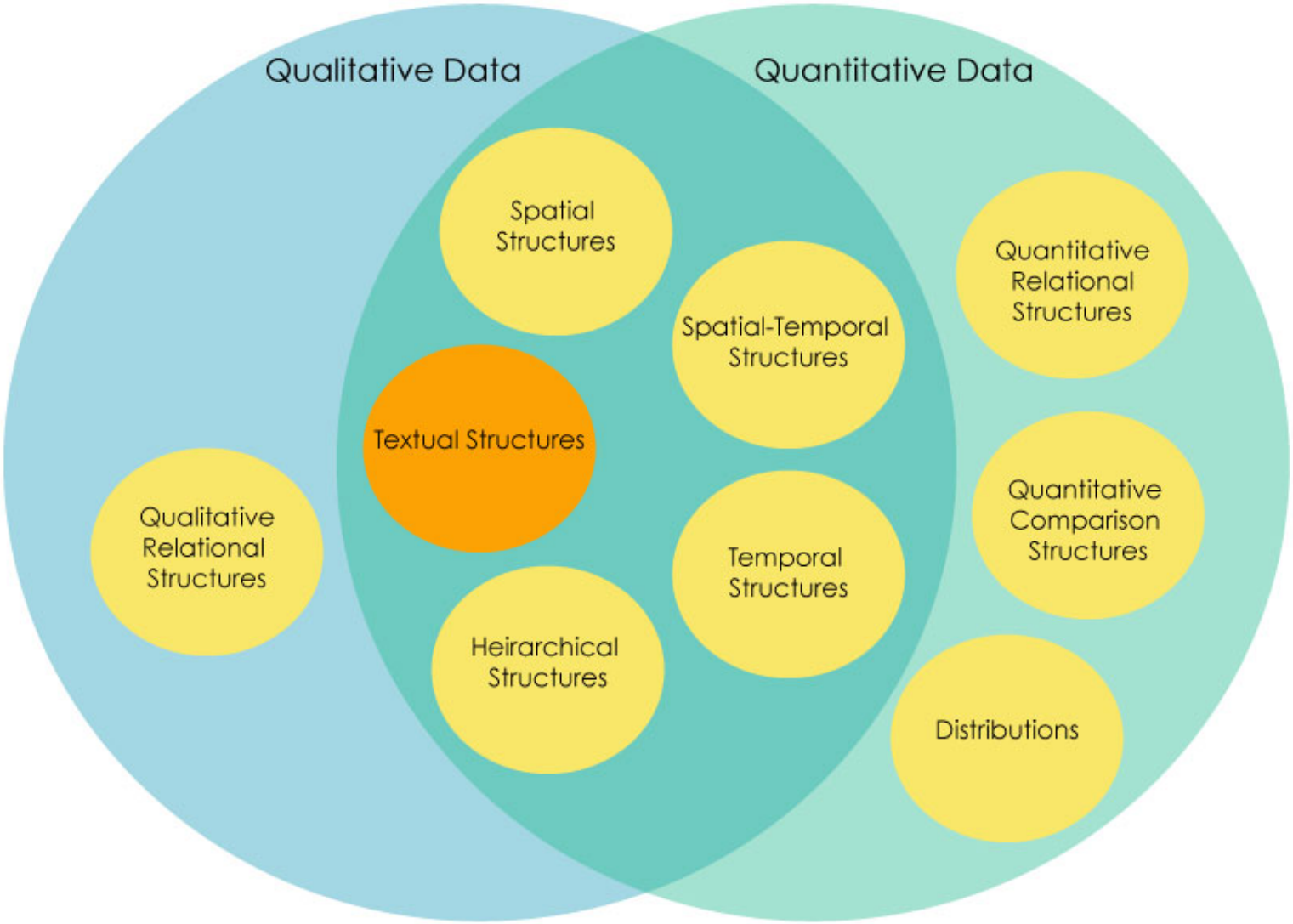
Qualitative Relational Structures

Networks

Sankey Diagram



Source: LLNL 2011. Data is based on DOE/EIA-0384(2010), October 2011. If this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy, under whose auspices the work was performed. Distributed electricity represents only retail electricity sales and does not include self-generation. EIA reports flows for hydro, wind, solar and geothermal in BTU-equivalent values by assuming a typical fossil fuel plant "heat rate." (see EIA report for explanation of change to geothermal in 2010). The efficiency of electricity production is calculated as the total retail electricity delivered divided by the primary energy input into electricity generation. End use efficiency is estimated as 80% for the residential, commercial and industrial sectors, and as 25% for the transportation sector. Totals may not equal sum of components due to independent rounding. LLNL-MI-410527


Qualitative Data
Quantitative Data
Spatial Structures
Spatial-Temporal Structures
Quantitative Relational Structures
Textual Structures
Quantitative Comparison Structures
Qualitative Relational Structures
Temporal Structures
Heirarchical Structures
Distributions

Qualitative Data: Textual Structures

Word Cloud

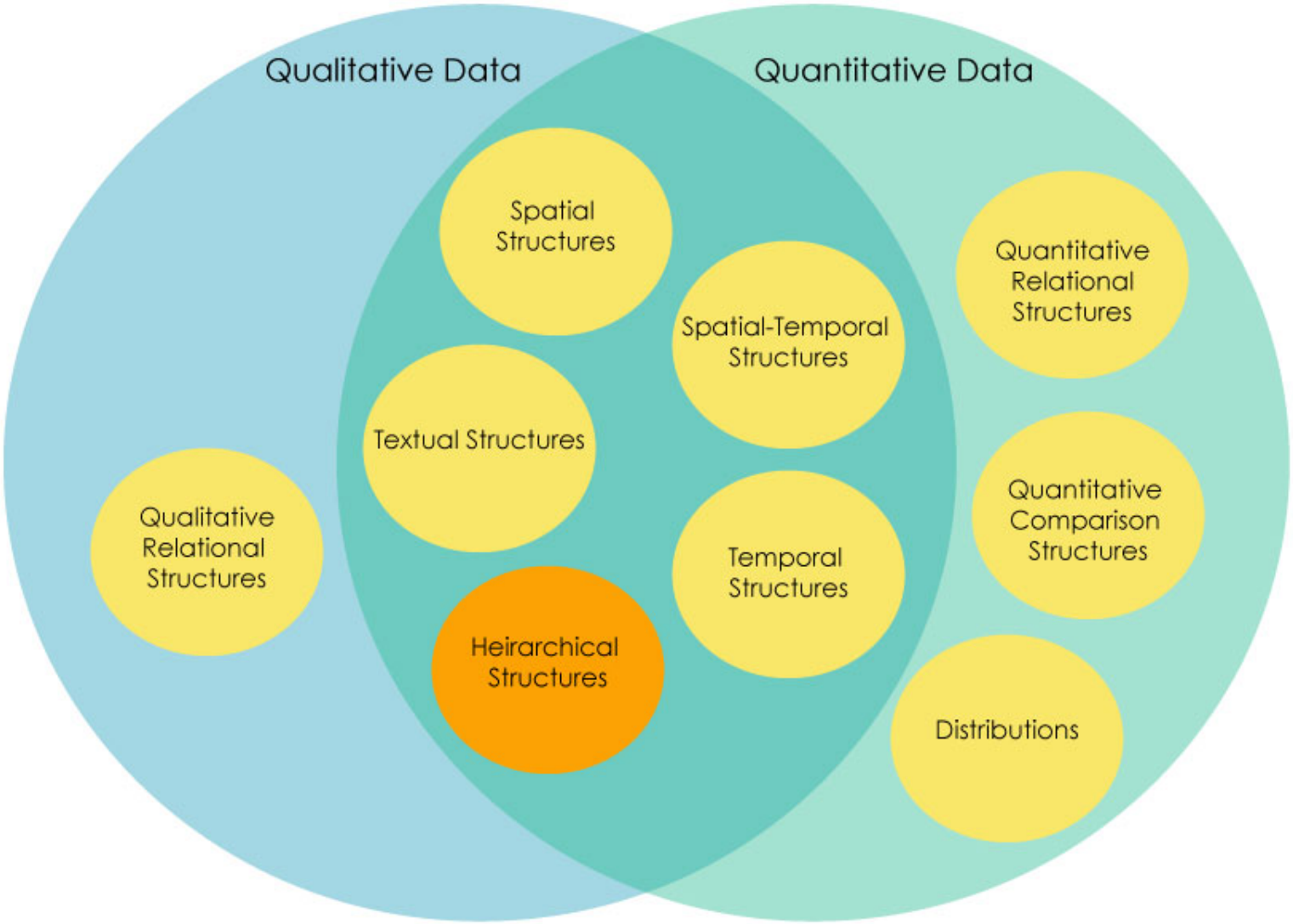
Image source:
https://www.washingtonpost.com/news/the-fix/wp/2015/06/16/the-many-many-things-that-are-great-according-to-donald-trump/

Qualitative Data: Textual Structures

Word Tree

Image Source:
https://developers.google.com/chart/interactive/docs/gallery/wordtree

Also see:
http://www.chrisharrison.net/index.php/Visualizations/WebTrigrams


Qualitative Data
Quantitative Data
Spatial Structures
Spatial-Temporal Structures
Quantitative Relational Structures
Textual Structures
Quantitative Comparison Structures
Qualitative Relational Structures
Temporal Structures
Heirarchical Structures
Distributions

Figurative Trees

See Book:

The Book of Trees
Visualizing Branches of Knowledge

Manuel Lima

Loyset Liédet
Tree of cosanguinity
1471

Image Source:
http://visualoop.com/blog/16793/vintage-infodesign-53

Vertical Trees

First level of abstraction.

Flow charts, hierarchies

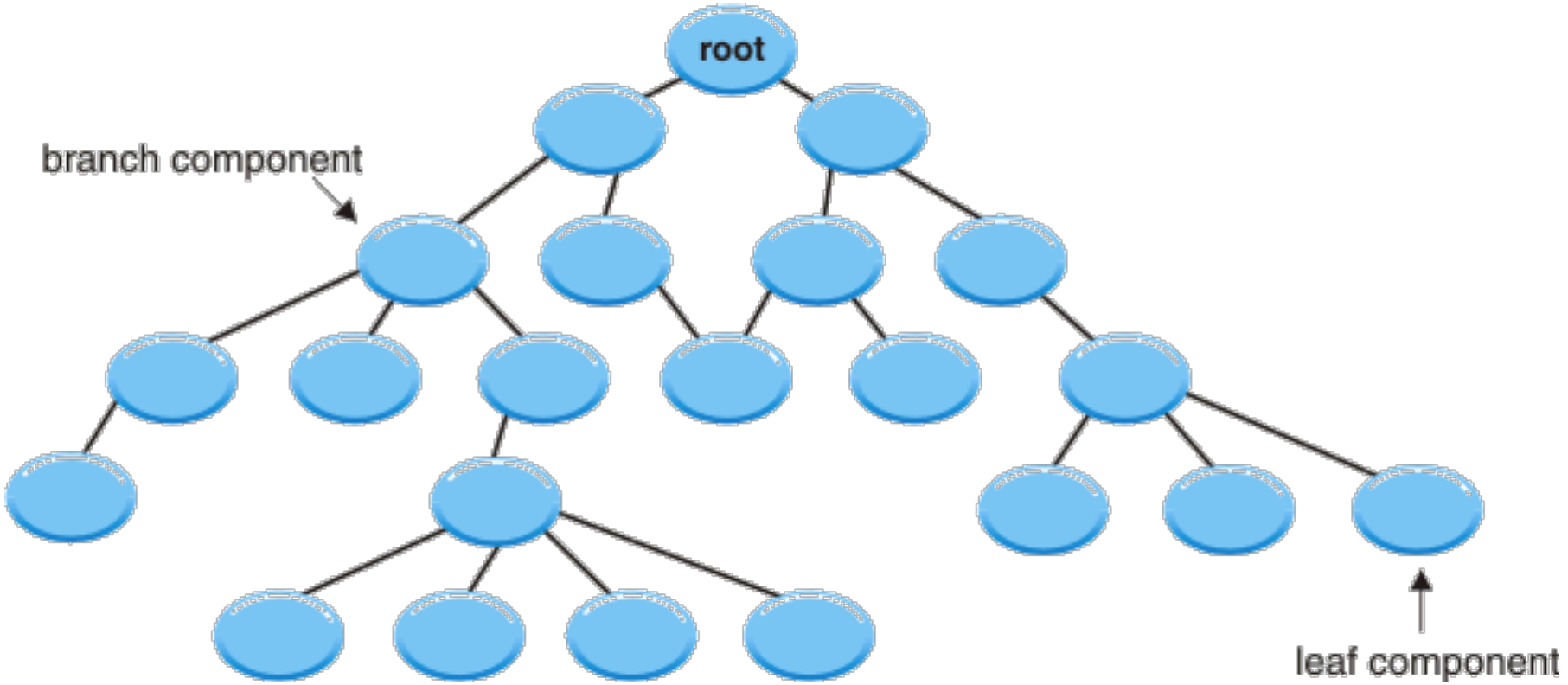


Image from: http://software.clearlake.ibm.com/CMVC/4.0/infocenter/htdocs/help/whatis/content/09.gif

Hierarchical Structures

Horizontal Trees

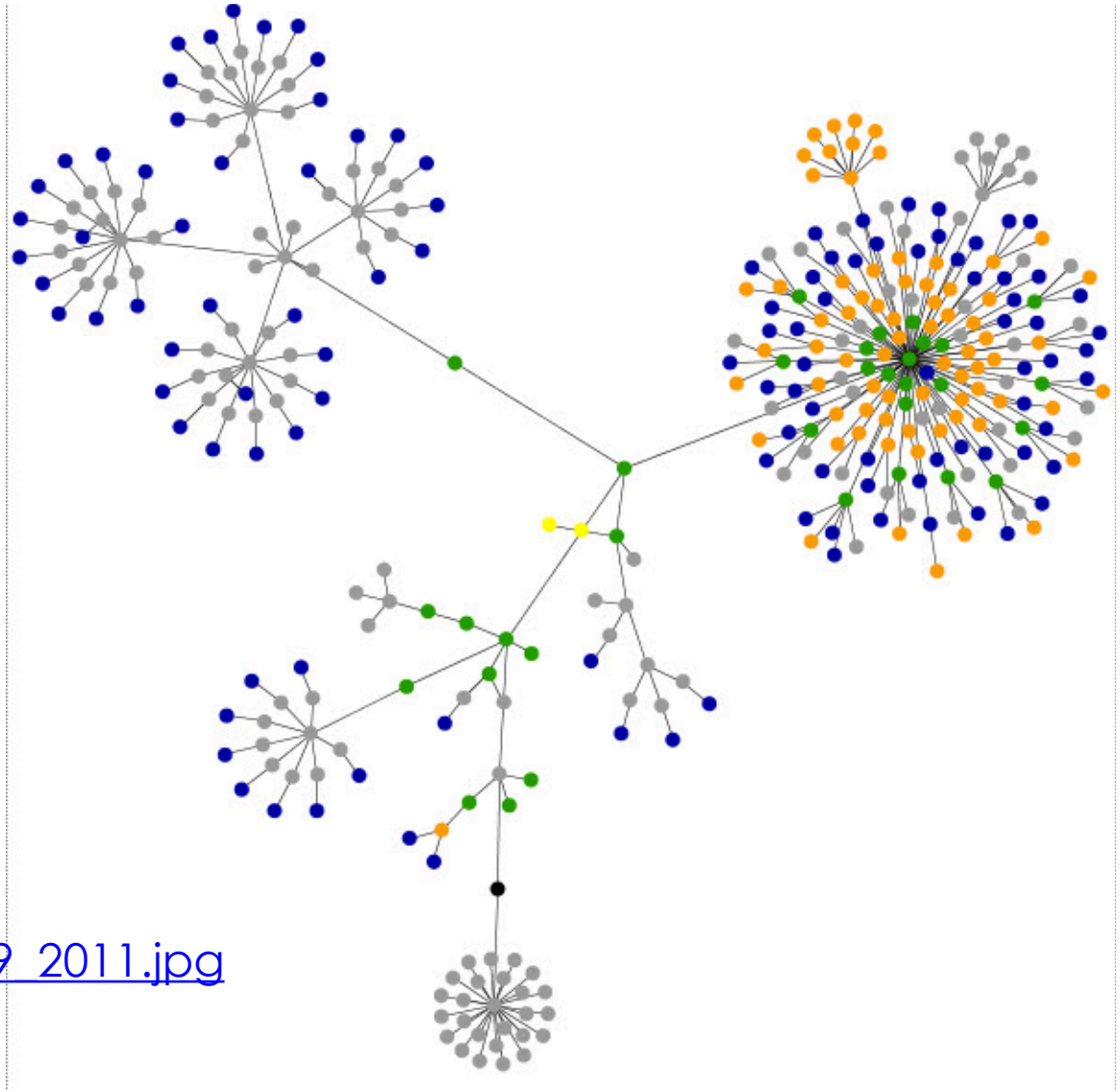
Image Source:
https://developers.google.com/chart/interactive/docs/gallery/wordtree

Also see:
http://www.chrisharrison.net/index.php/Visualizations/WebTrigrams

Hierarchical Structures

Multidirectional Trees

Example:
Marcel Salathé
Websites as Graphs
2006



Also see:
Yifan Hu
The Tree of Life
2011
http://yifanhu.net/TOL/tol_9_19_2011.jpg

Image from:
http://www.guylevans.co.uk/blog/wp-content/uploads/2010/04/Website-Graph.jpg

Hierarchical Structures

Radial Trees

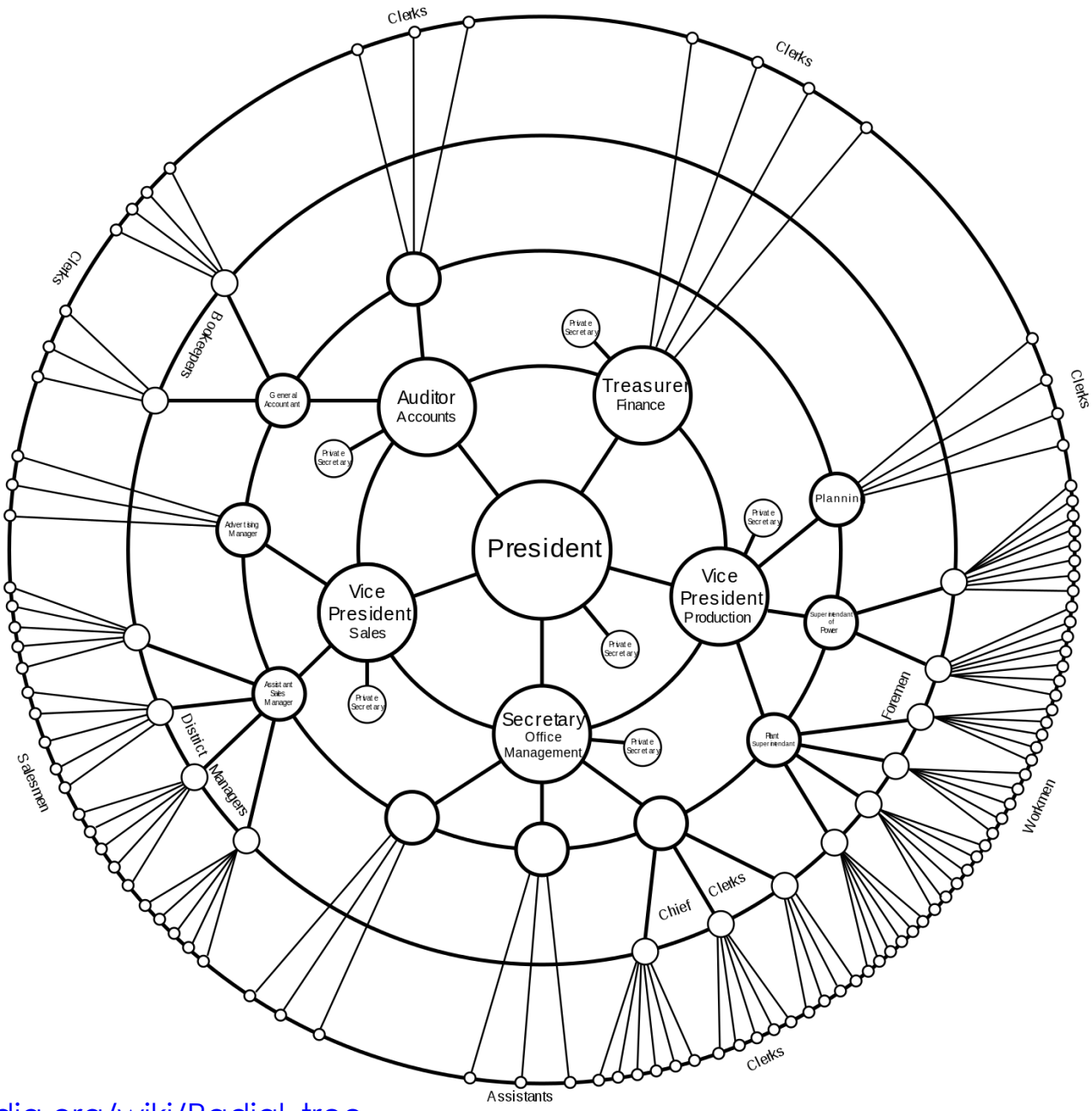
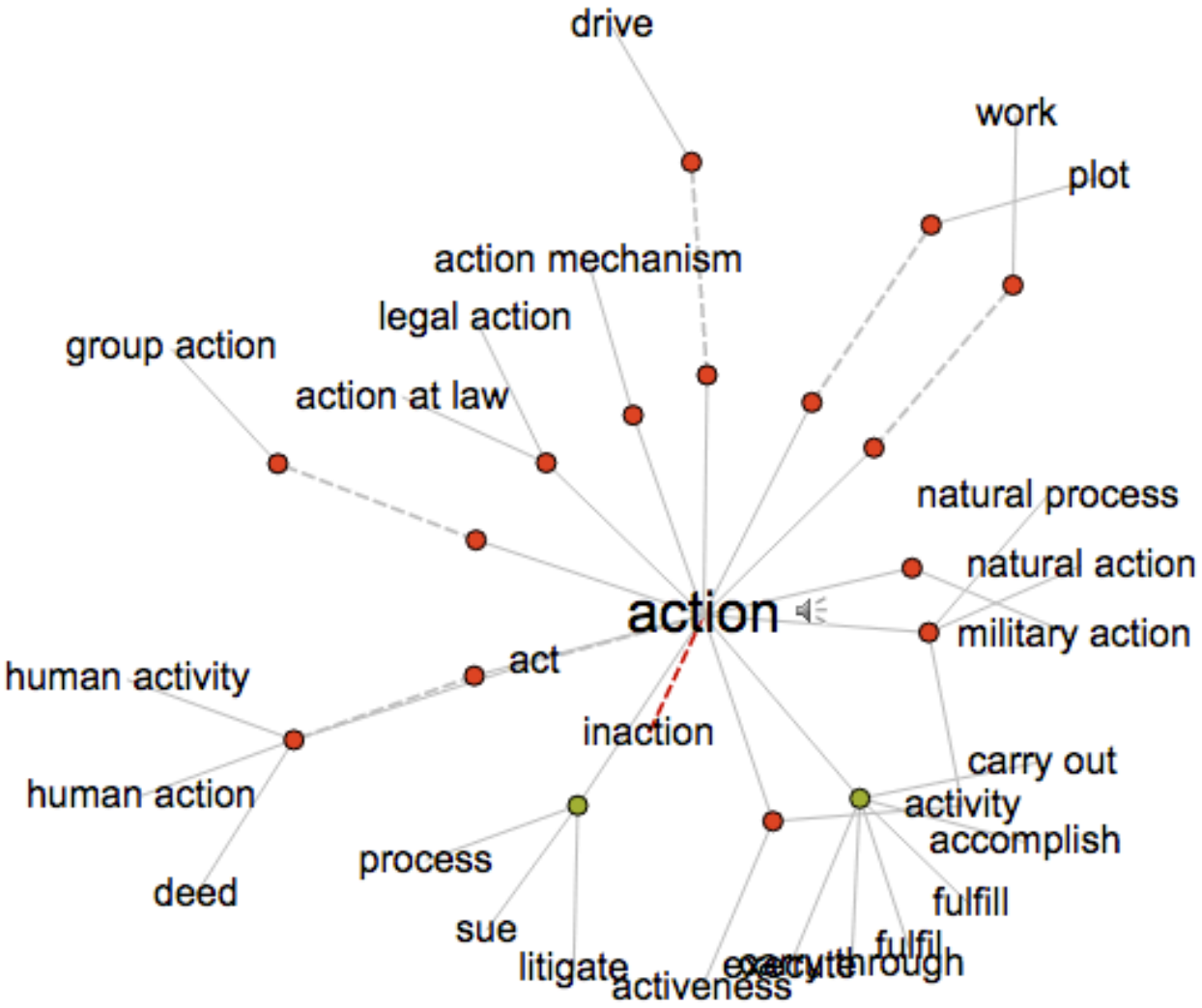


Image from: https://en.wikipedia.org/wiki/Radial_tree

Hierarchical Structures

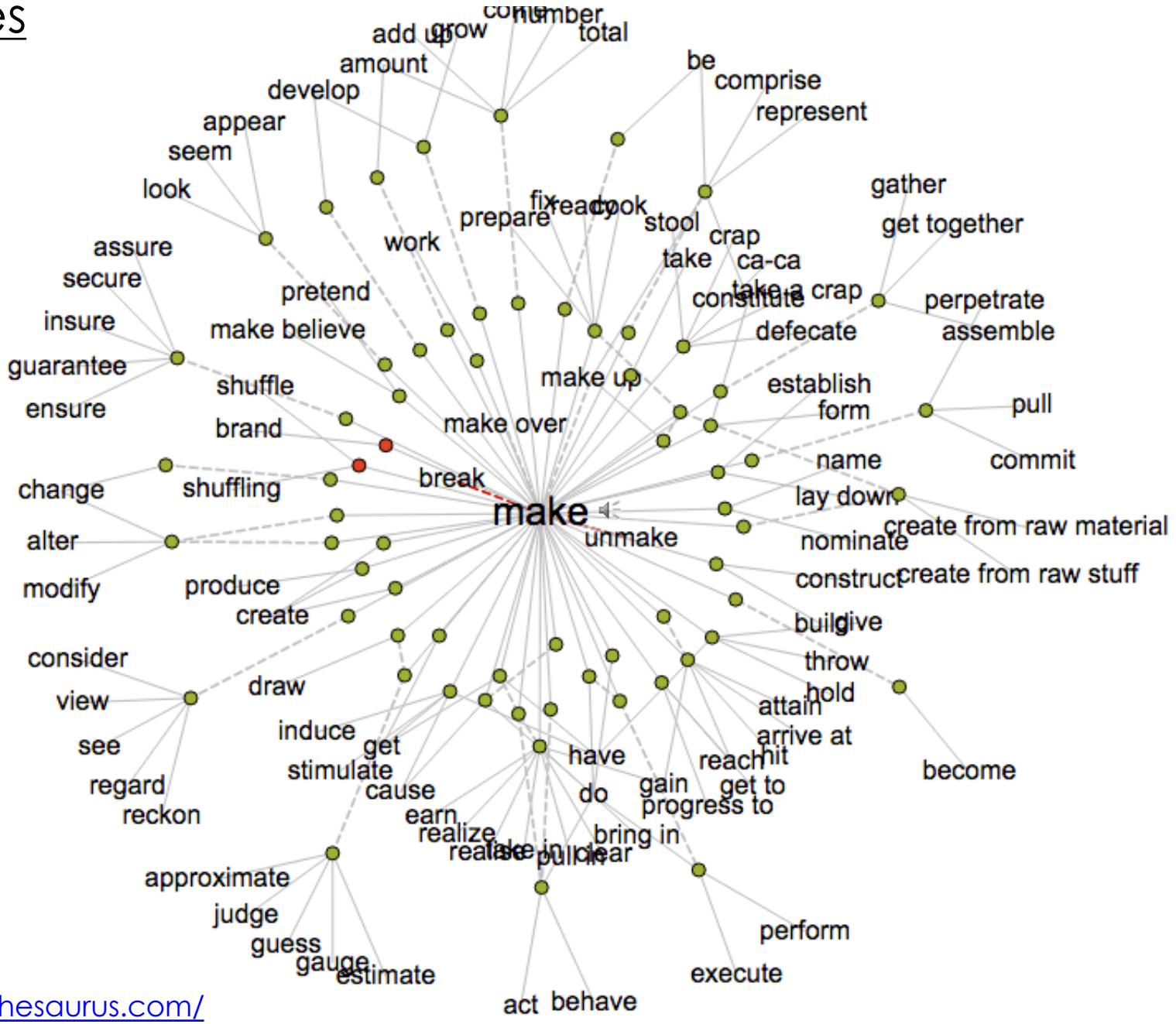
Radial Trees



http://www.visualthesaurus.com/

Hierarchical Structures

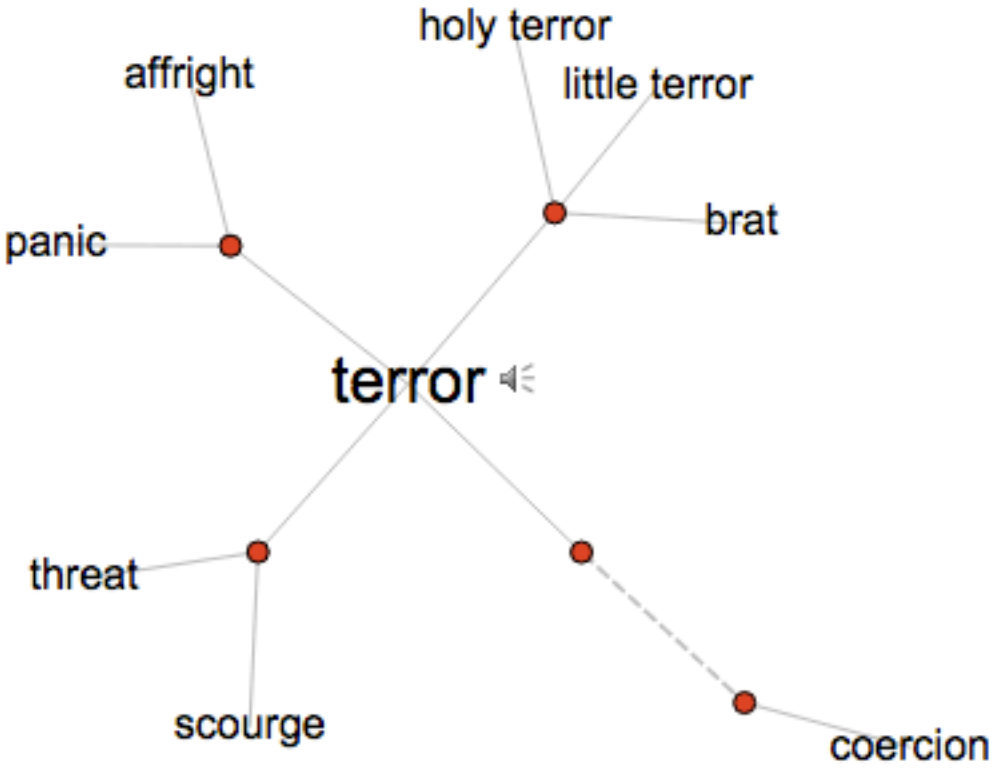
Radial Trees



http://www.visualthesaurus.com/

Hierarchical Structures

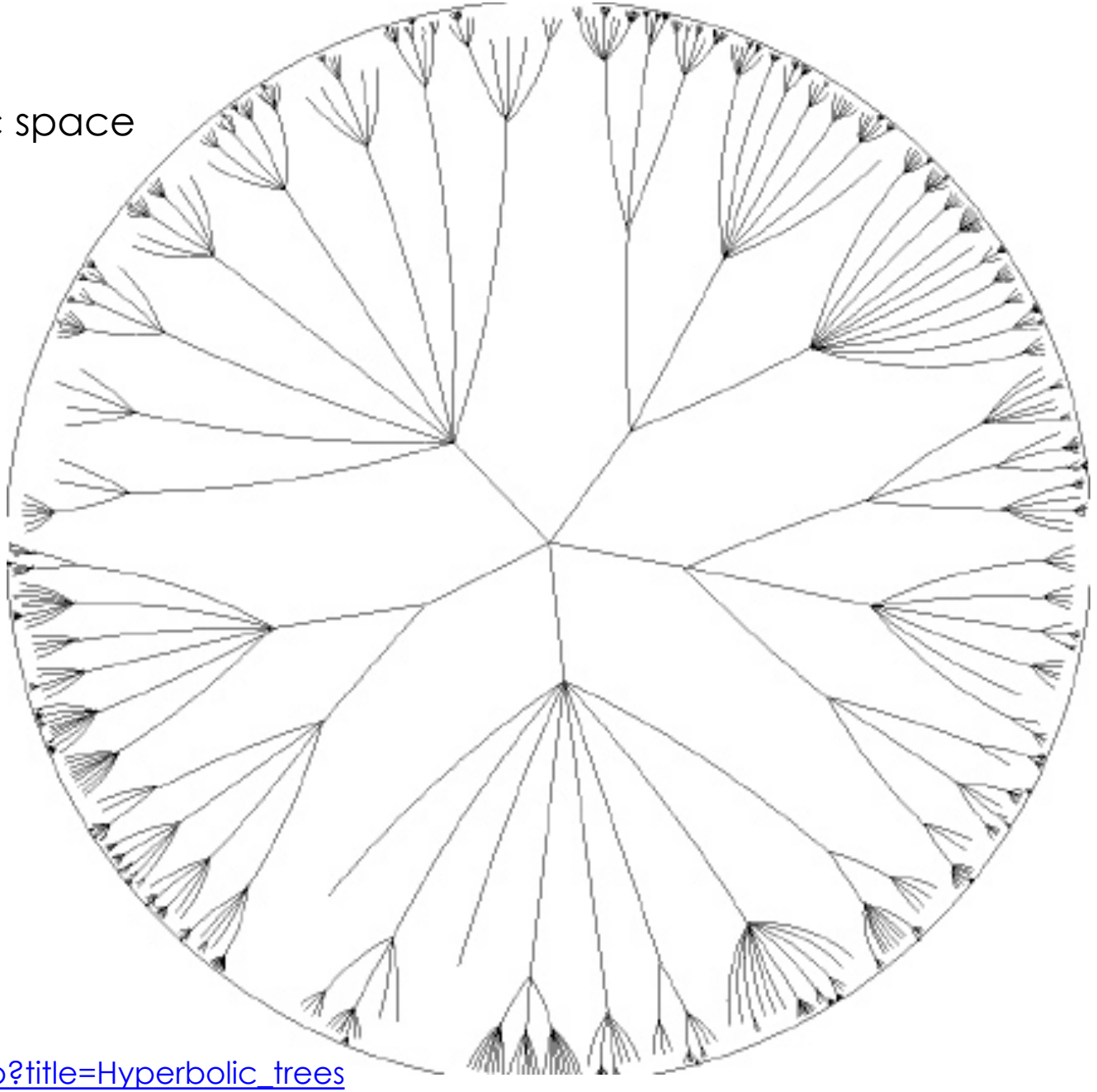
Radial Trees



http://www.visualthesaurus.com/

Hyperbolic Trees

Radial tree in hyperbolic space

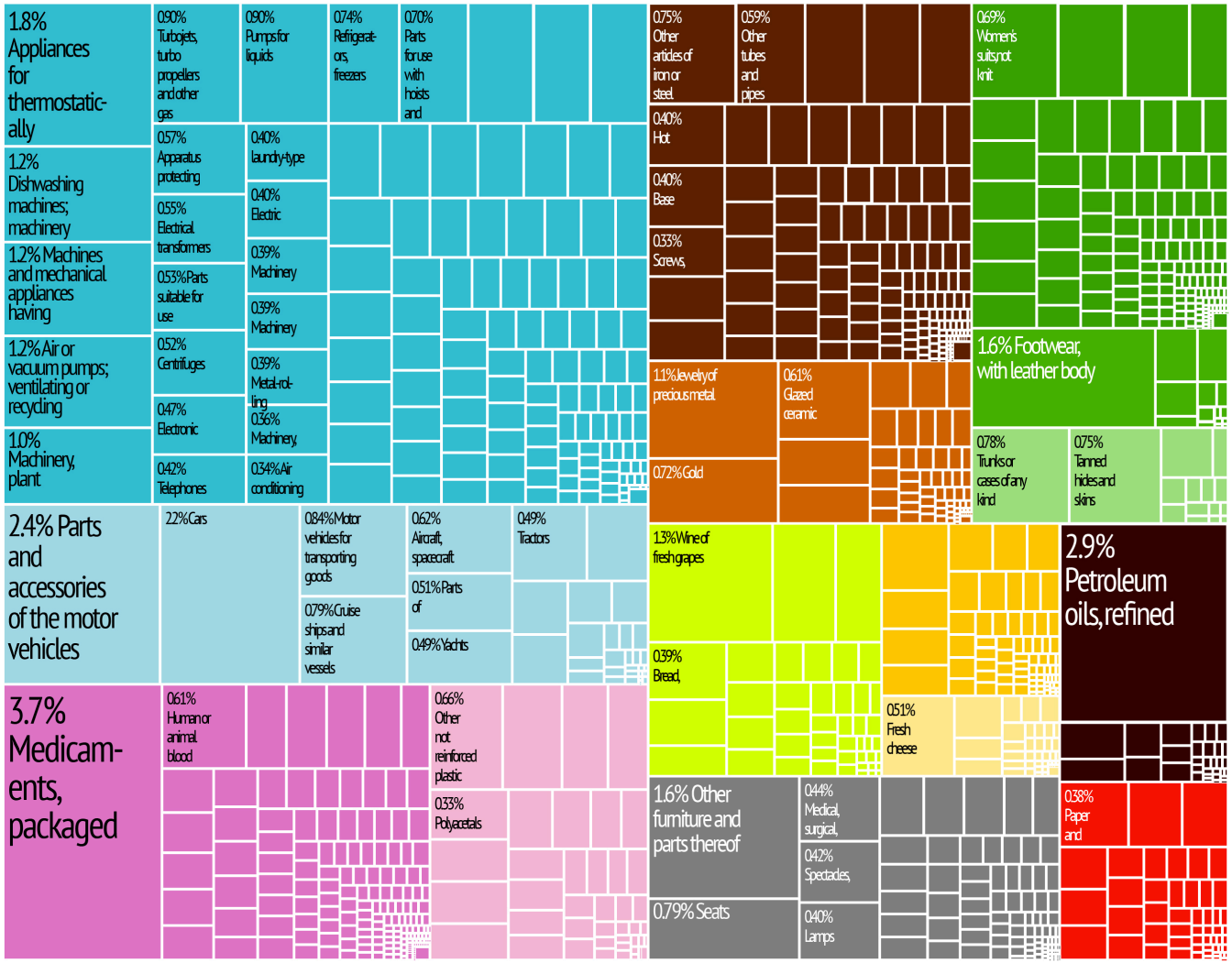


http://infovis-wiki.net/index.php?title=Hyperbolic_trees

Hierarchical Structures

Rectangular Treemaps

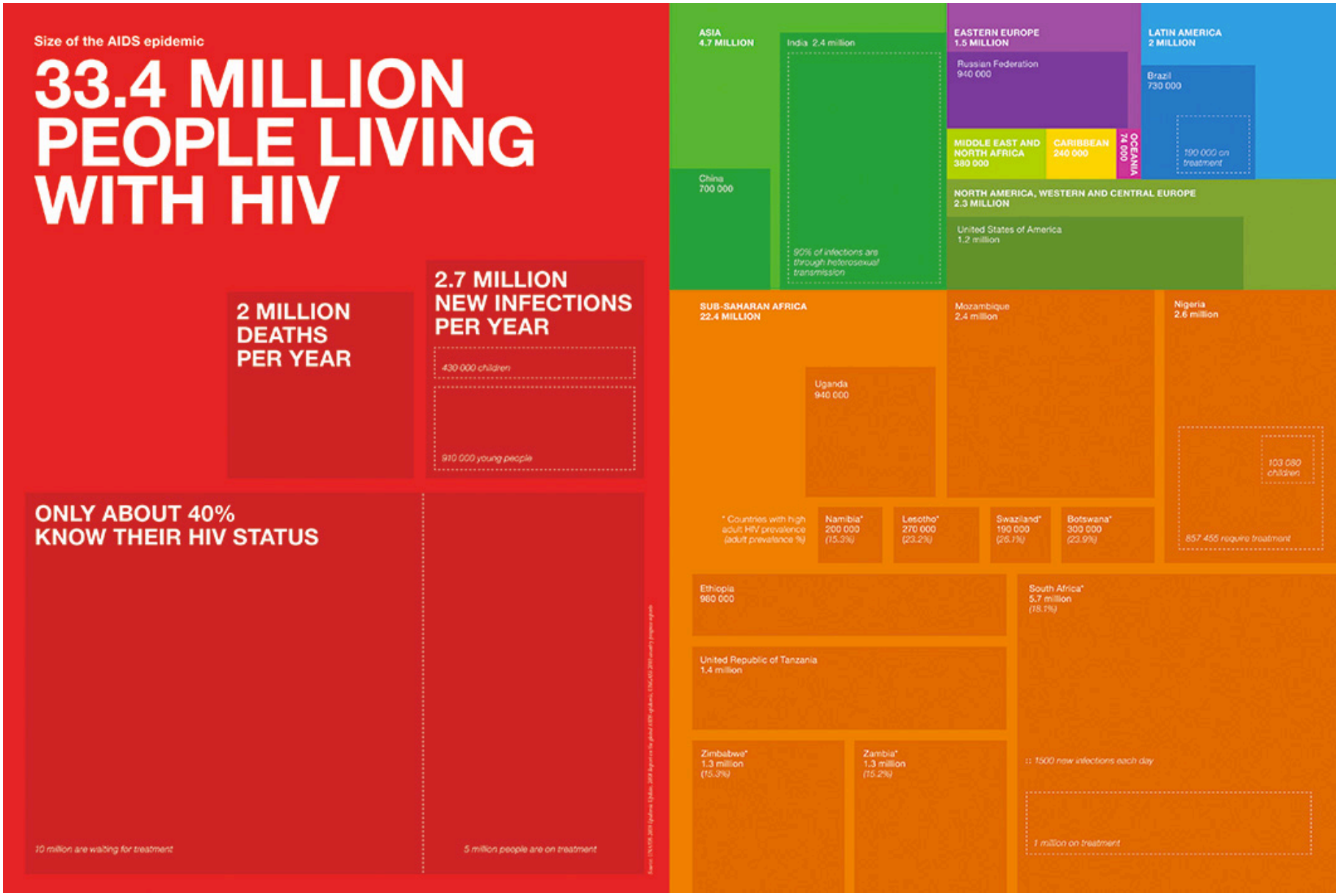
Uses nested rectangles to express hierarchy
Also communicates quantitative data, using size



https://commons.wikimedia.org/wiki/File:Italy_Export_Treemap.jpg

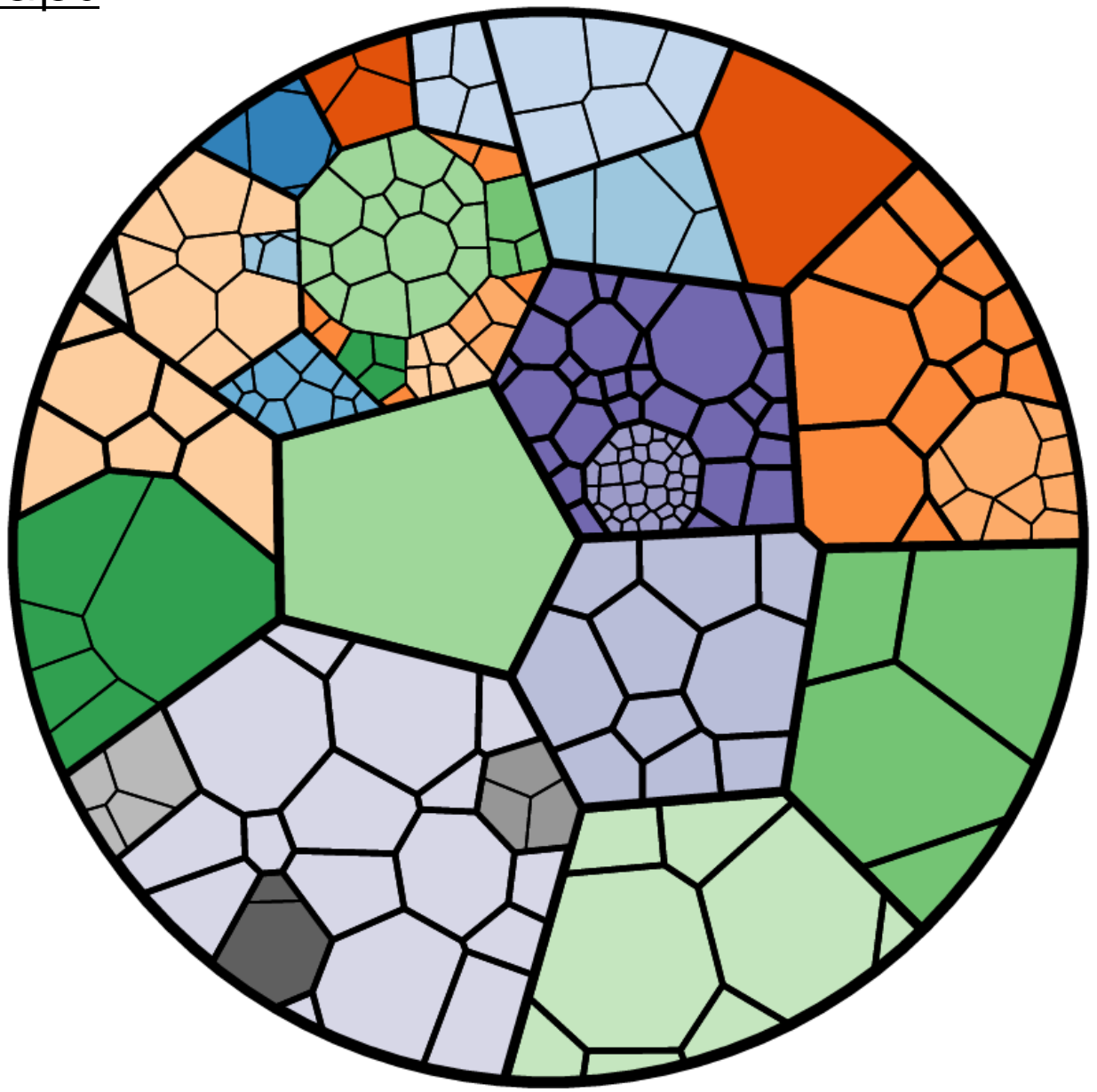
Hierarchical Structures

Rectangular Treemaps



http://arcadenw.org/article/scientific-visualization-unaids-treemaps-and-more

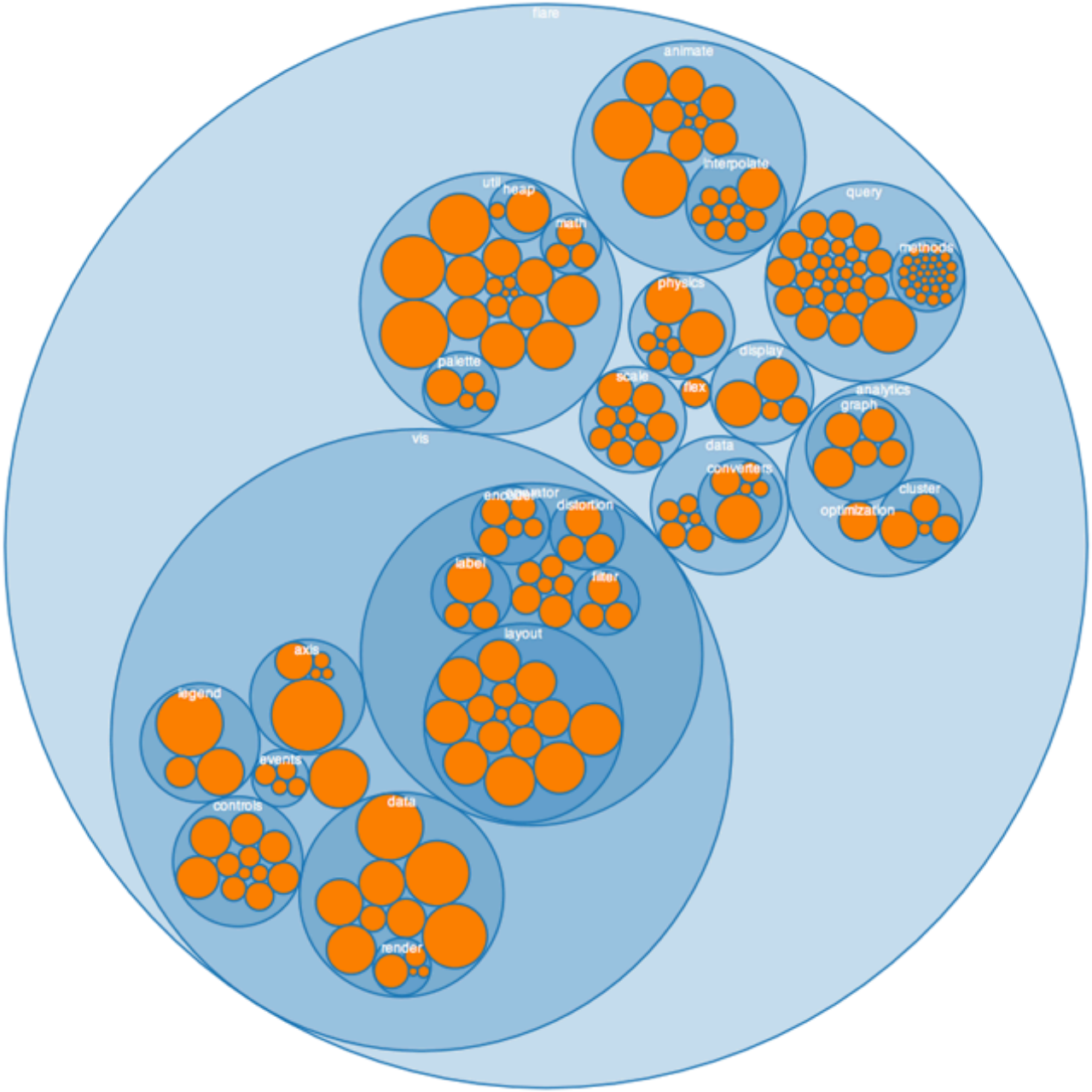
Voronoi Treemaps



http://cse512-14w.github.io/fp-plvines-djpeter/

Hierarchical Structures

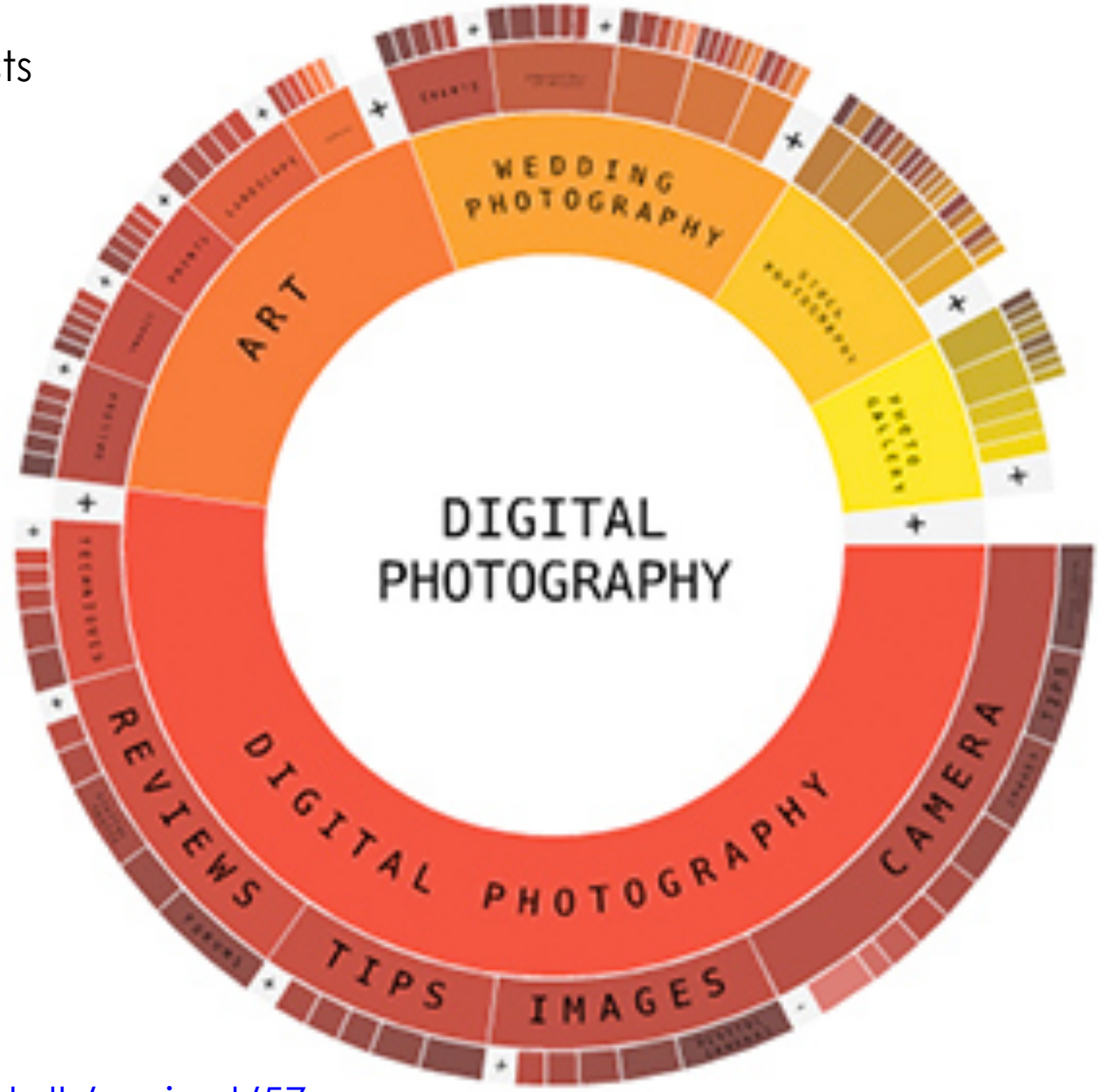
Circular Treemaps



http://homes.cs.washington.edu/~jheer/files/zoo/

Radial Treemaps

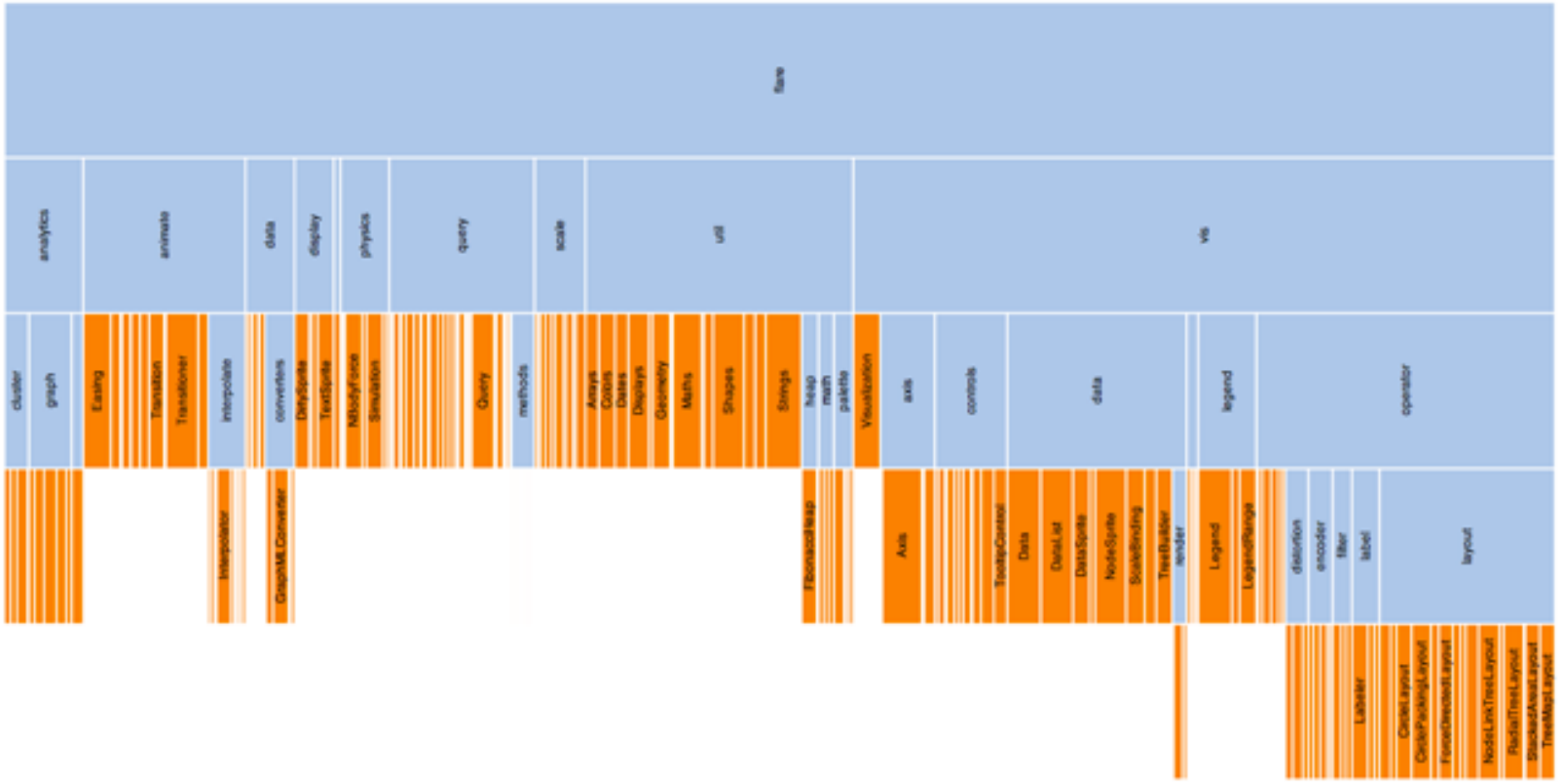
Also known as Sunbursts



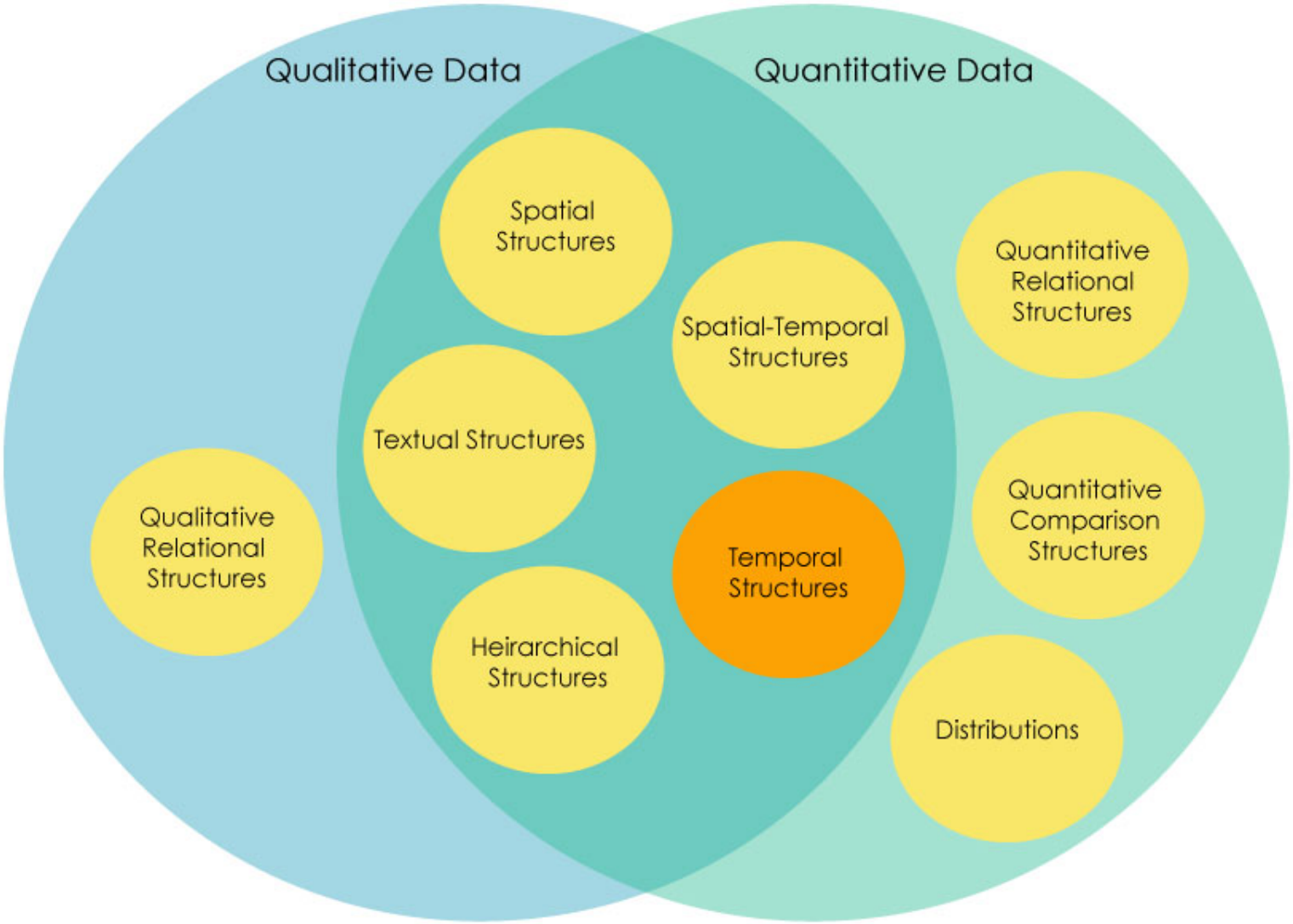
http://www.shiftcontrol.dk/project/57

Icicle Treemaps

Equivalent Sunbursts, in rectangular coordinates



http://homes.cs.washington.edu/~jheer/files/zoo/


Qualitative Data
Quantitative Data
Spatial Structures
Spatial-Temporal Structures
Quantitative Relational Structures
Textual Structures
Quantitative Comparison Structures
Qualitative Relational Structures
Temporal Structures
Heirarchical Structures
Distributions

Timelines

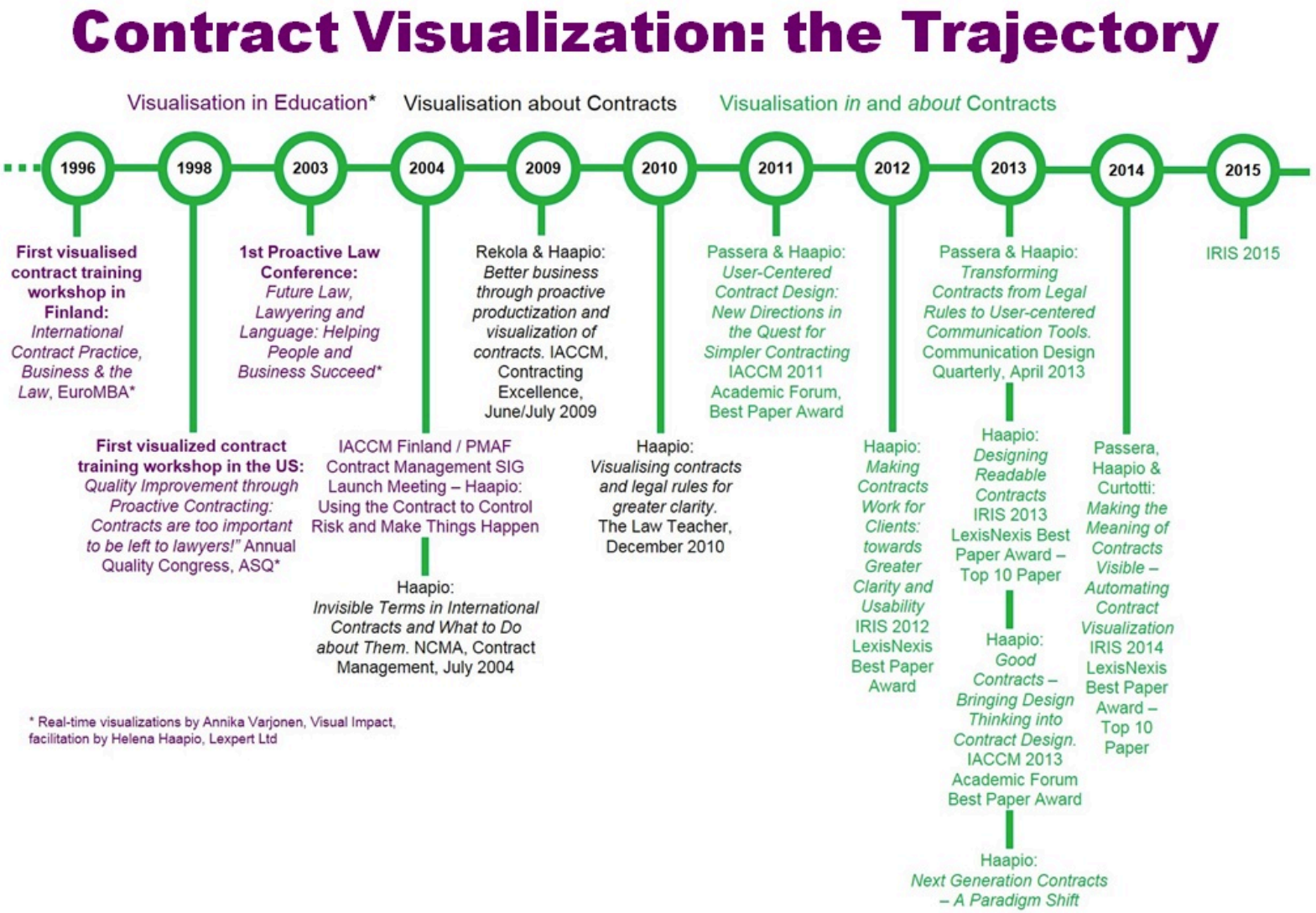


Image Source: http://www.lexpert.com/our-approach/visualization/

Temporal Structures

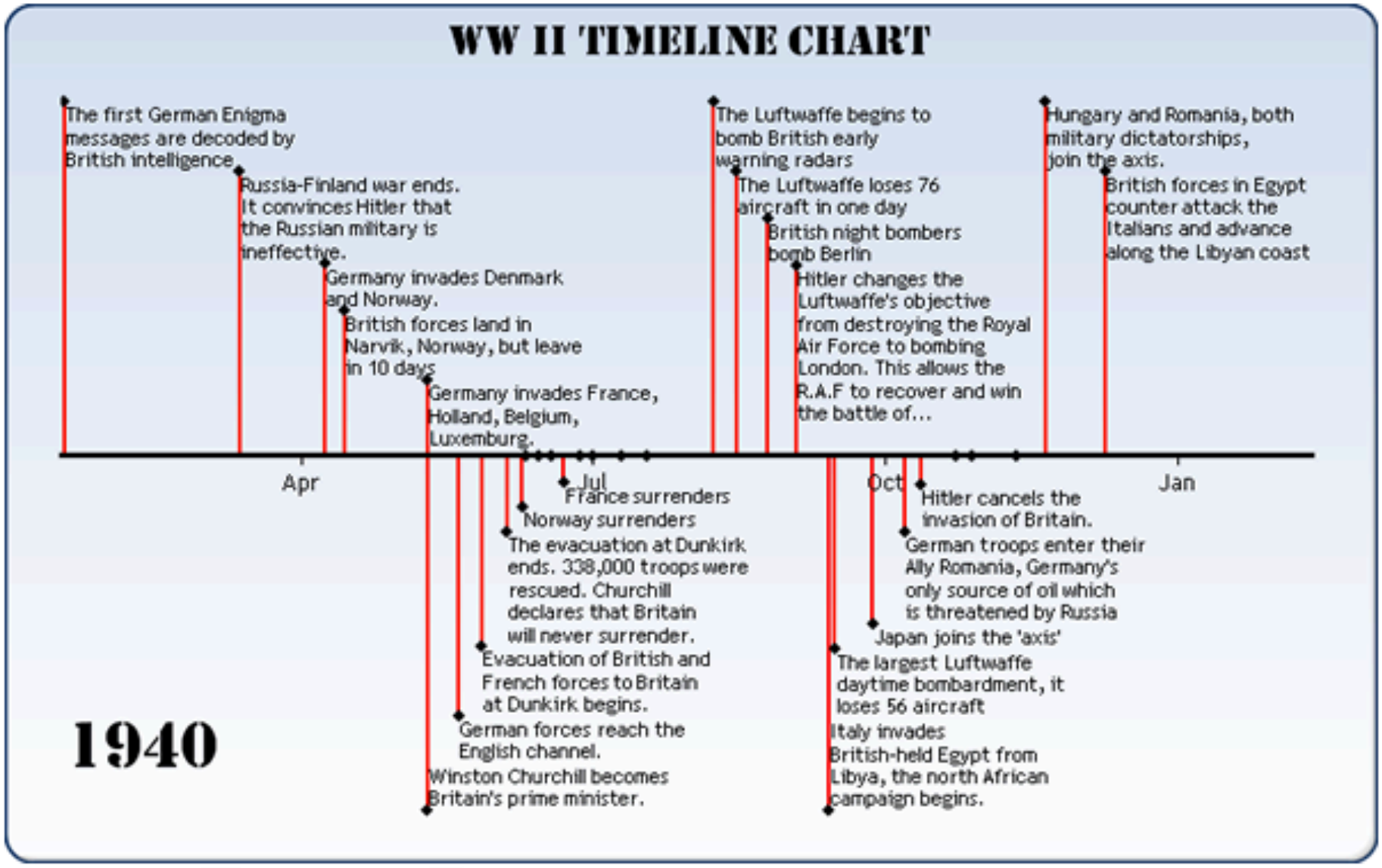


Image source: http://support2.dundas.com/Default.aspx?article=1359

Also see: http://www.concerthotels.com/100-years-of-rock/

Temporal Structures

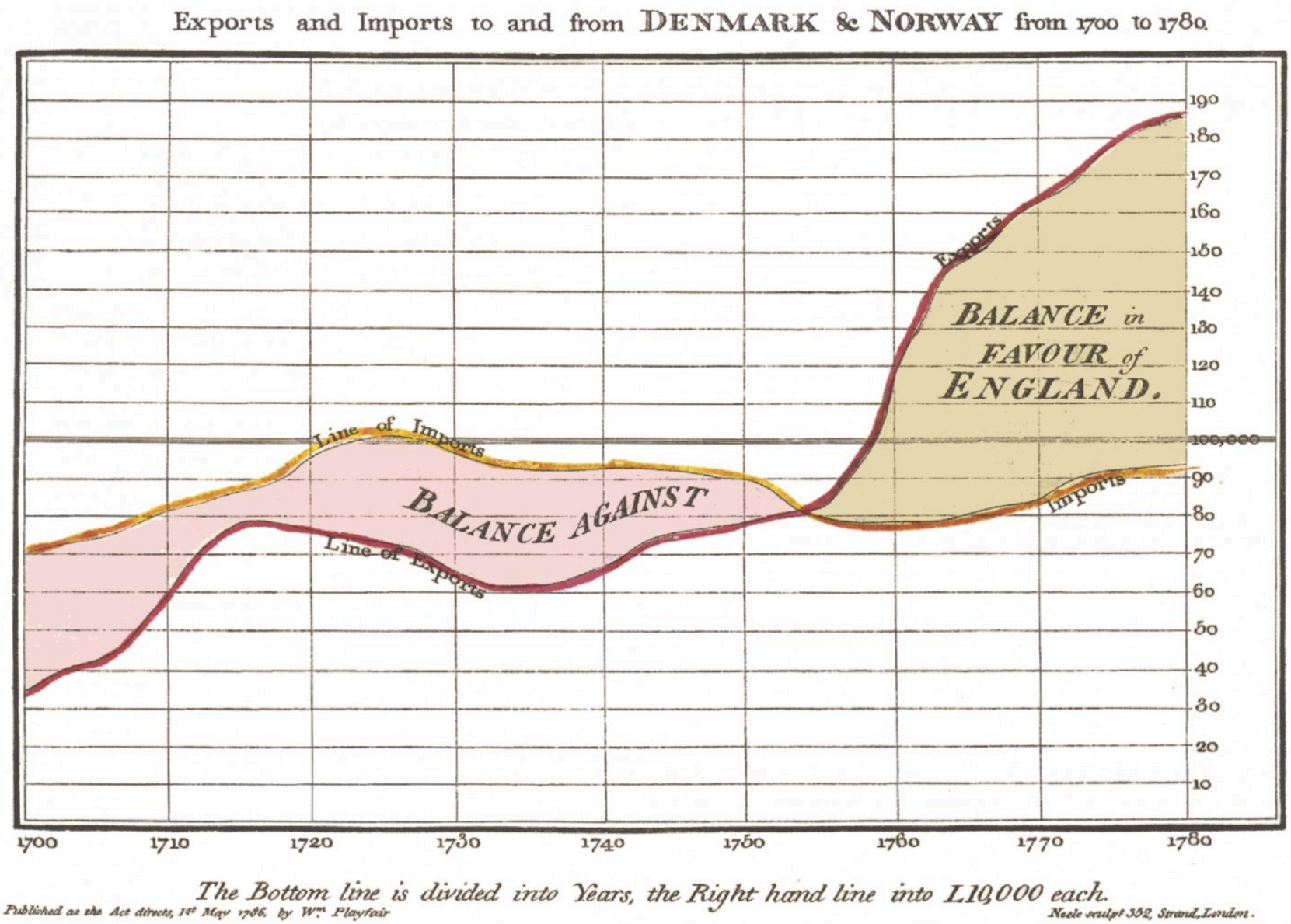
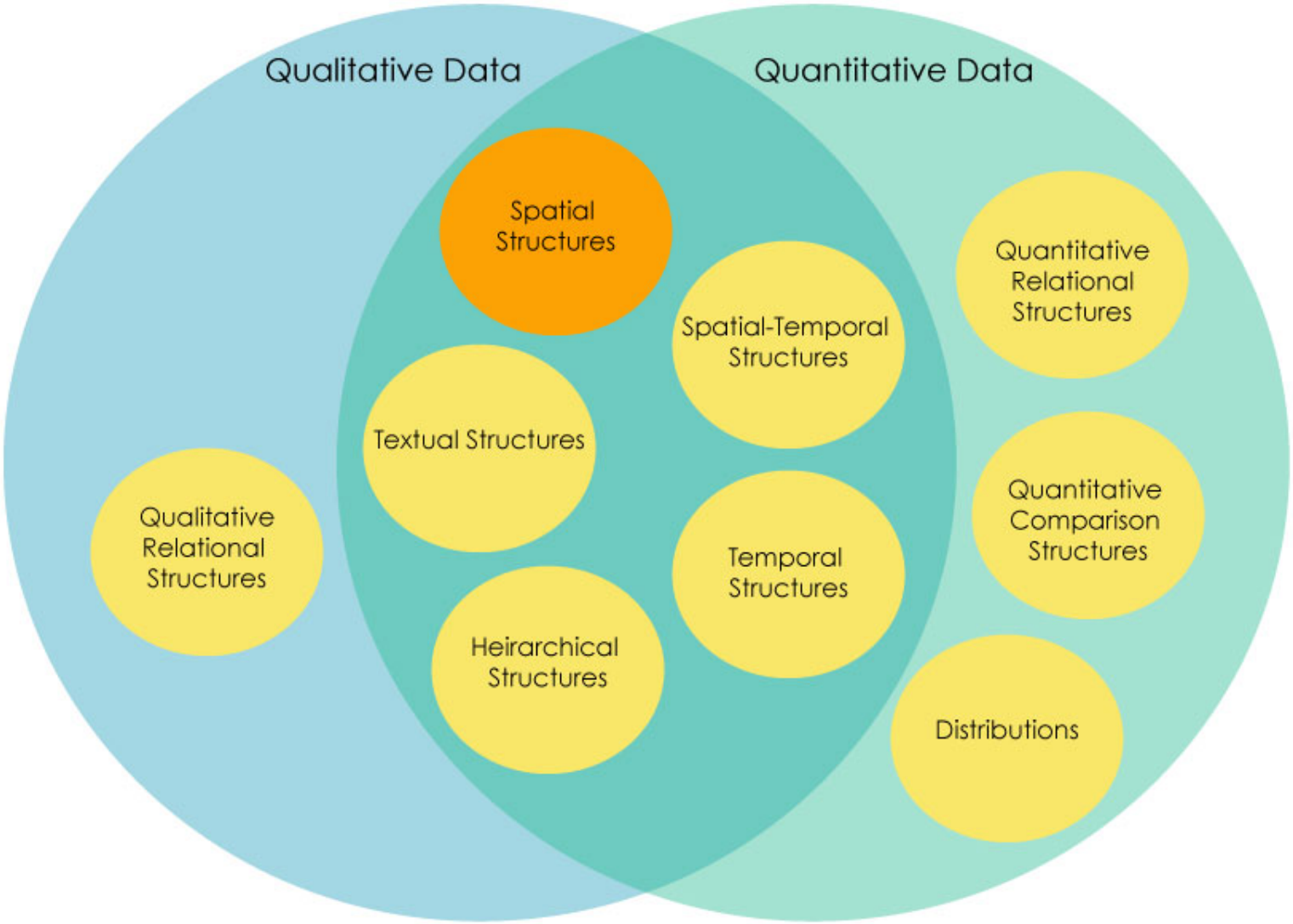
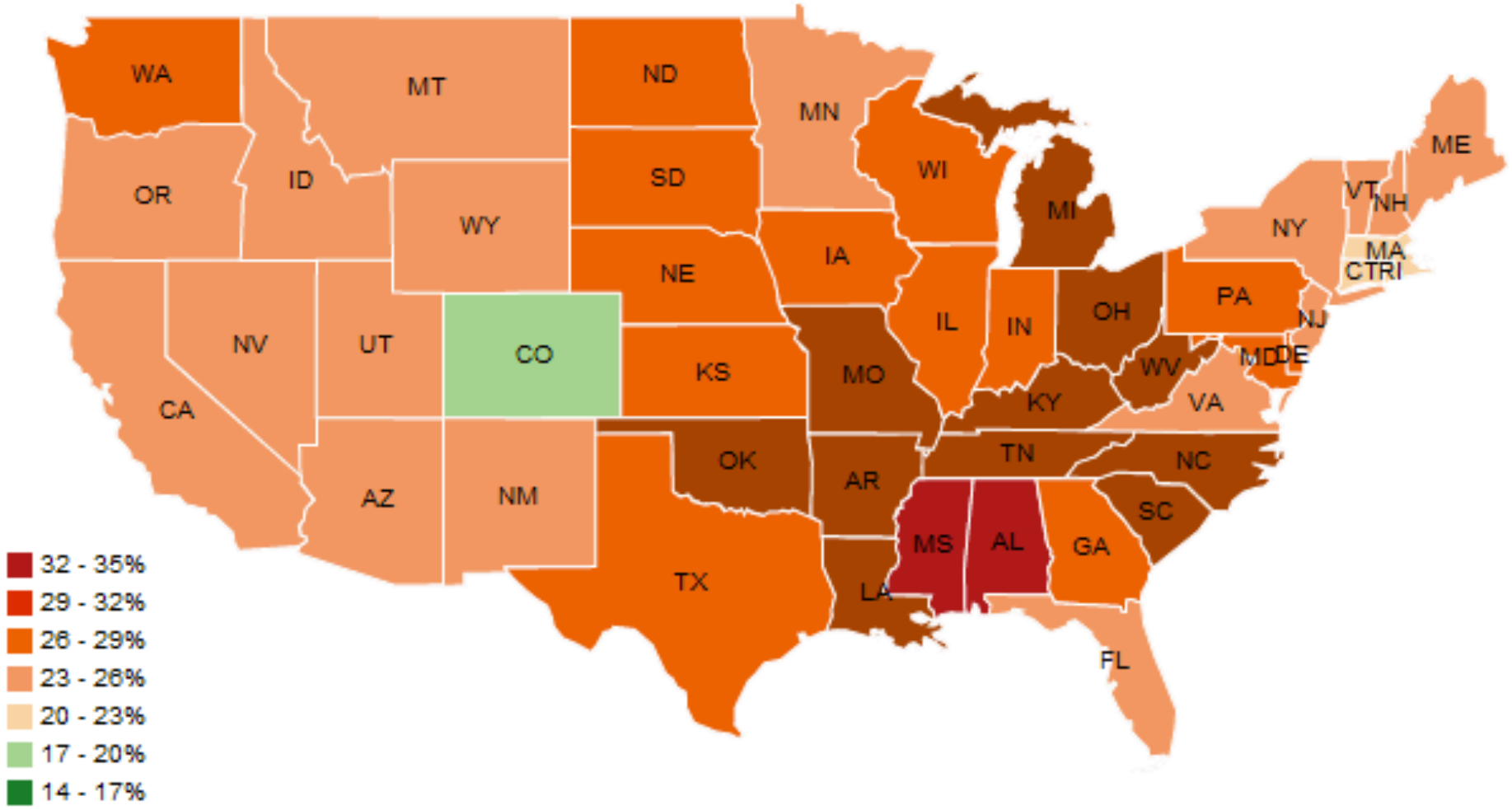


Image Source: http://visual.ly/exports-and-imports-and-denmark-norway-1700-1780


Qualitative Data
Quantitative Data
Spatial Structures
Spatial-Temporal Structures
Quantitative Relational Structures
Textual Structures
Quantitative Comparison Structures
Qualitative Relational Structures
Temporal Structures
Heirarchical Structures
Distributions

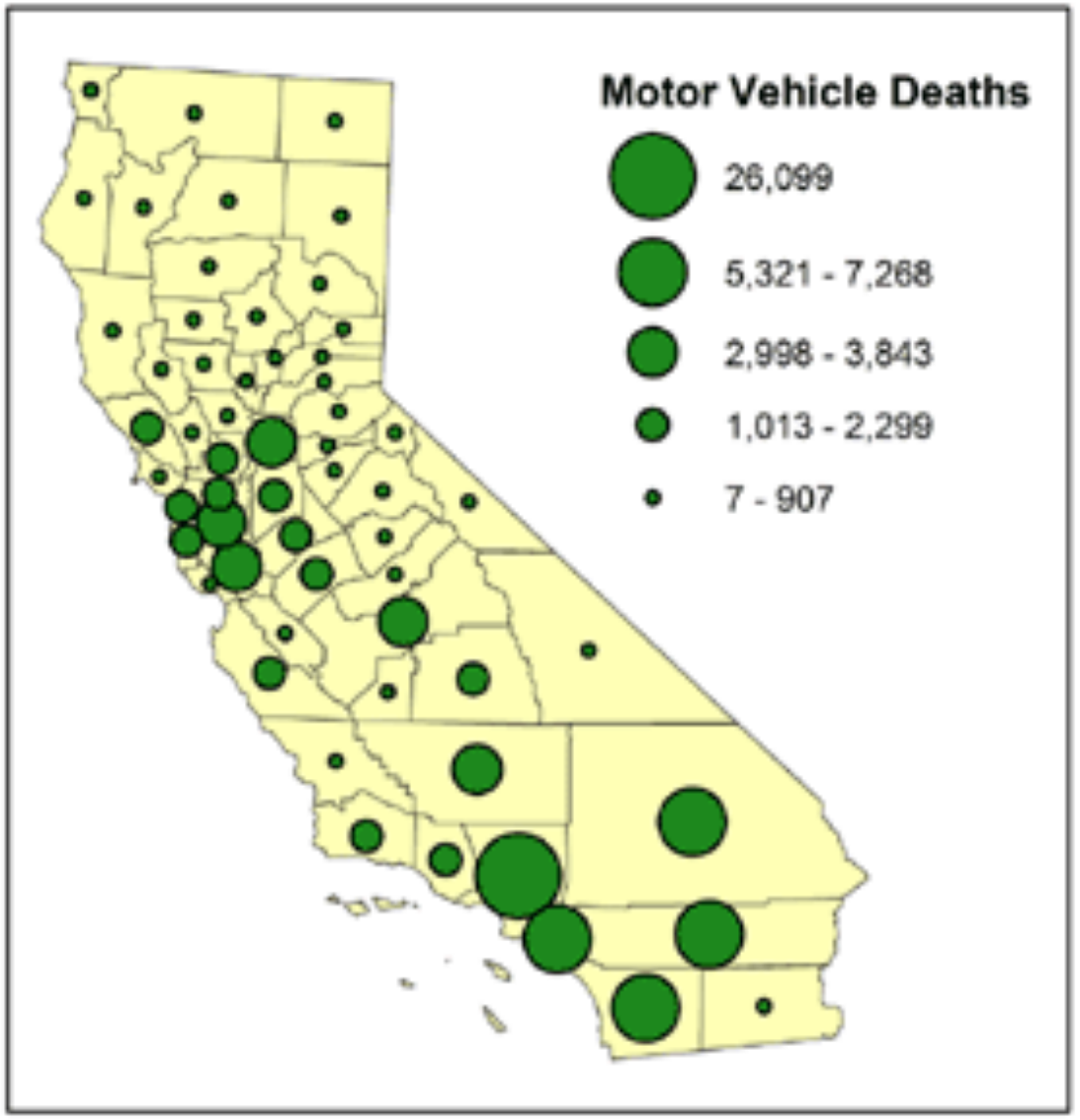
Spatial Structures: Maps

Choropleth Maps



http://homes.cs.washington.edu/~jheer/files/zoo/

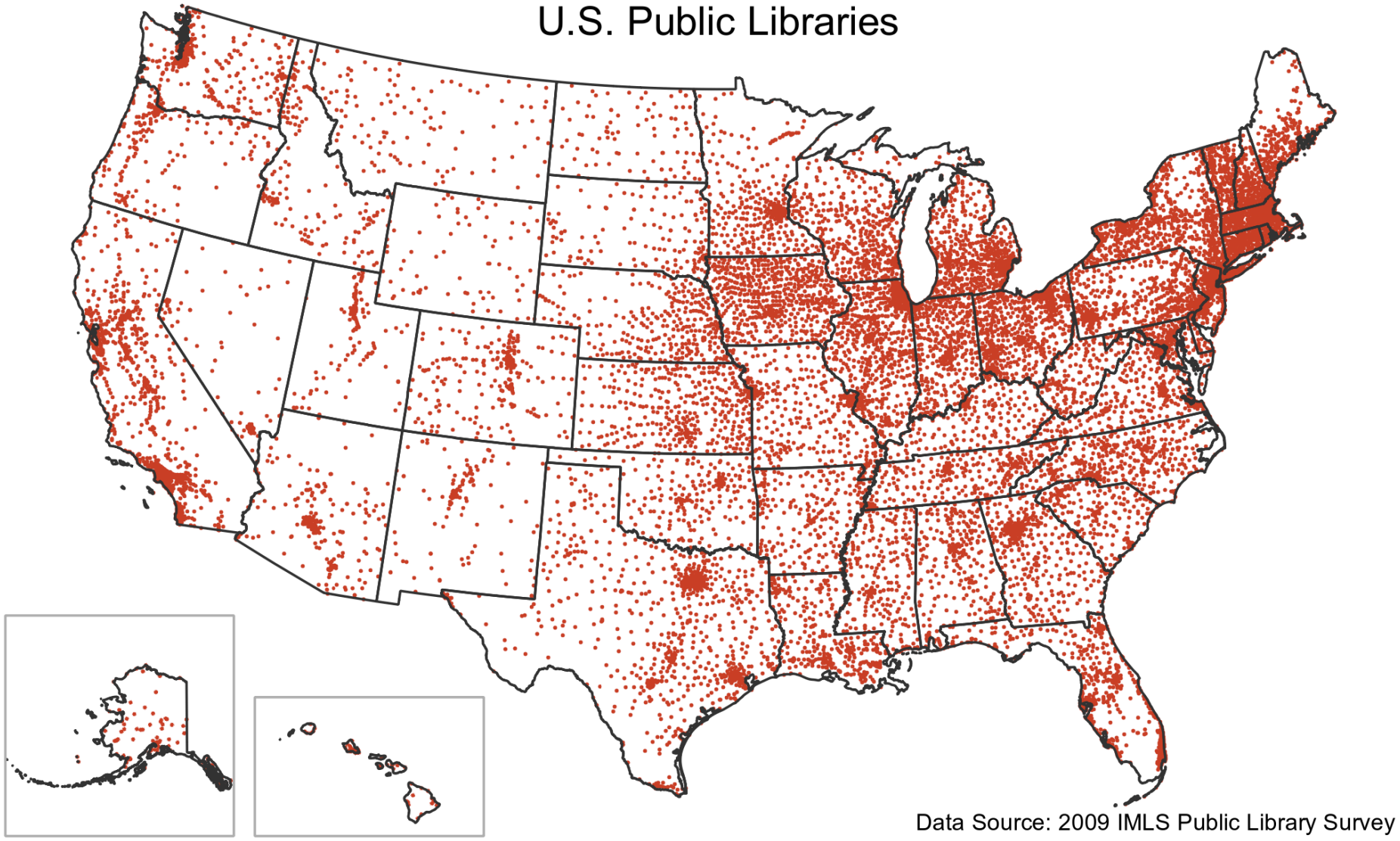
Graduated Symbol Maps



https://www.e-education.psu.edu/geog486/node/1869

Spatial Structures: Maps

Dot Distribution Maps



http://gothos.info/category/resources/

Also see: http://demographics.coopercenter.org/DotMap/index.html

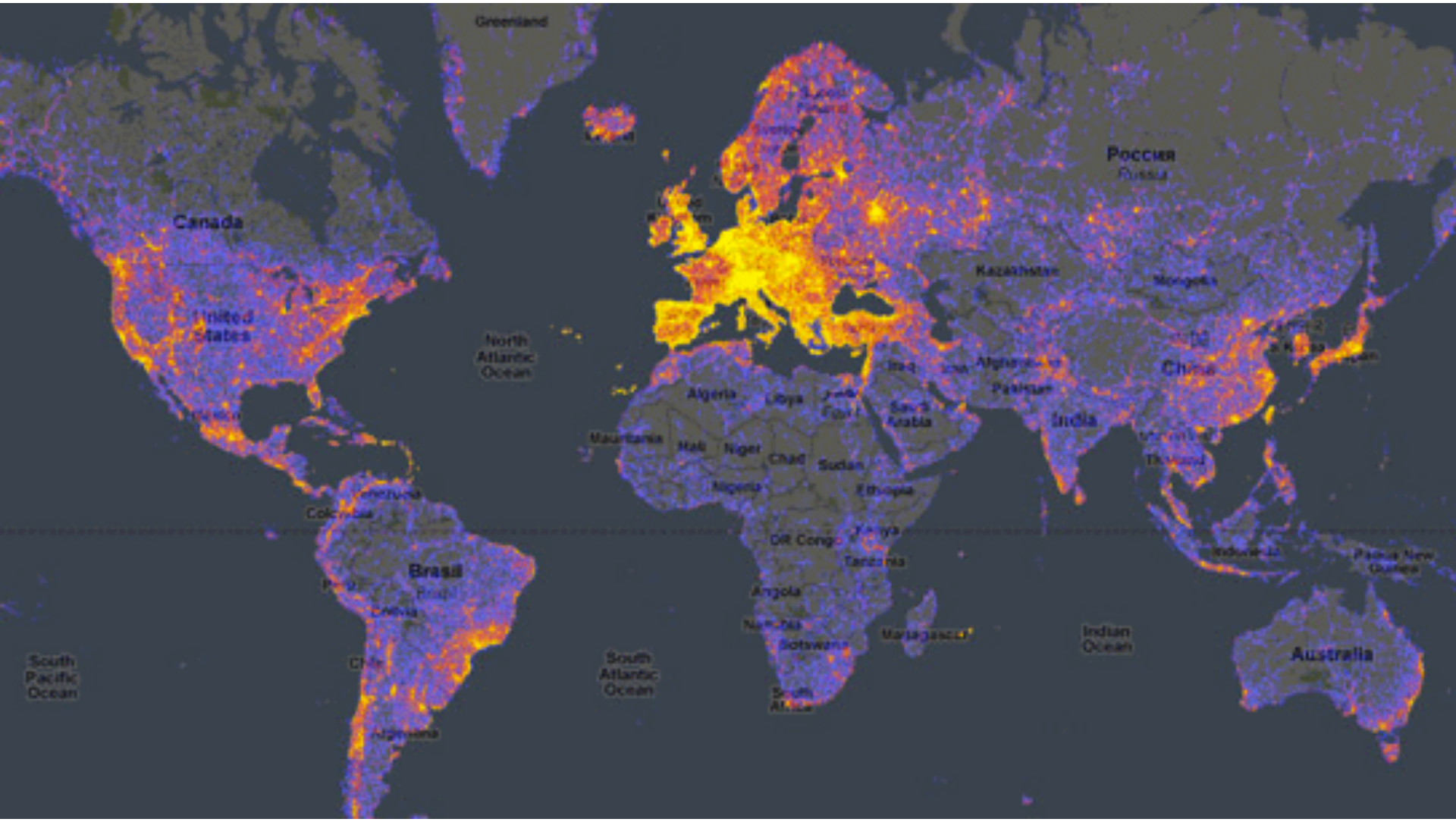
Spatial Structures: Maps

Heat maps

Frequency of Events
Topography
Density

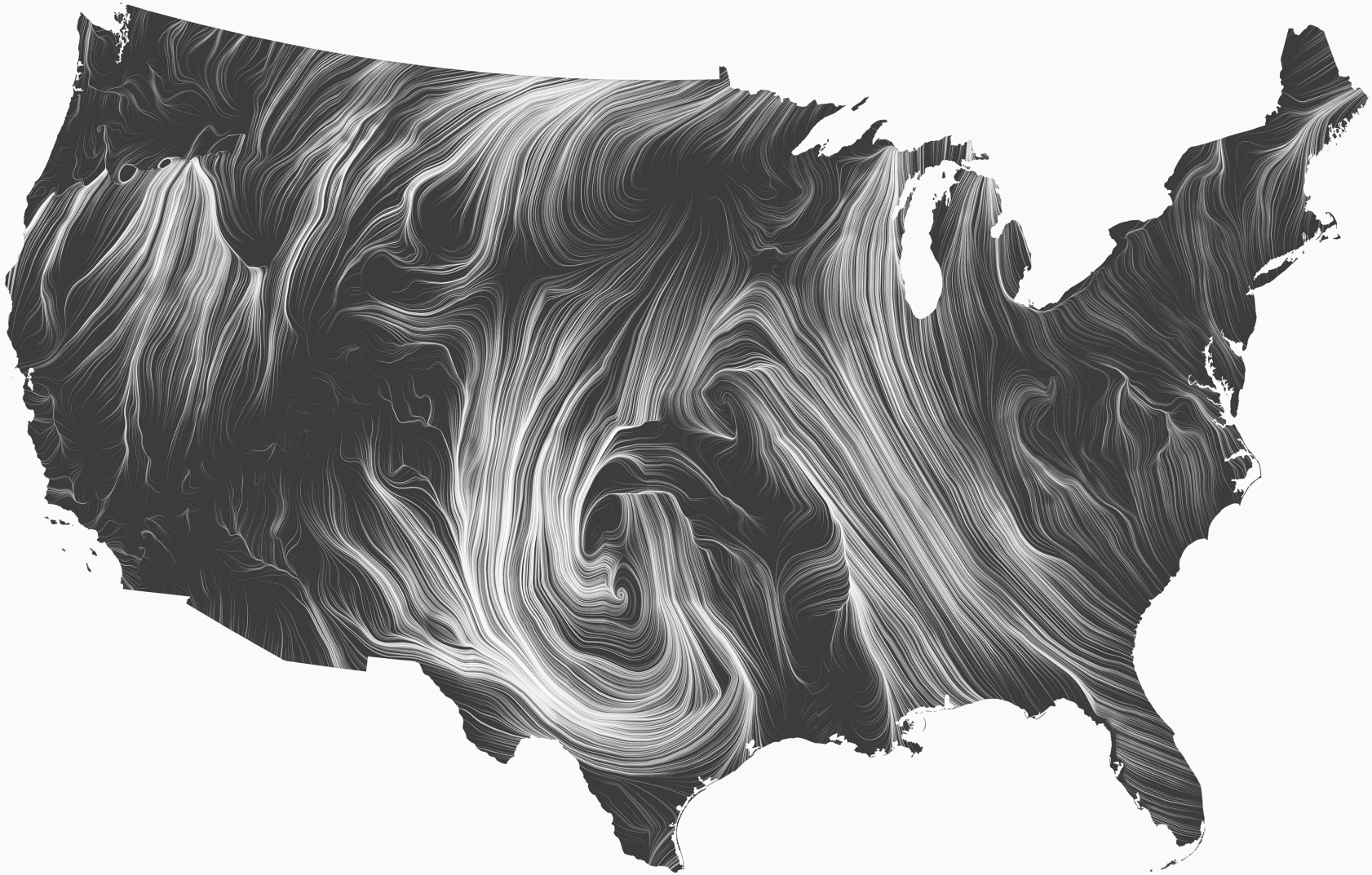
Spatial Structures: Maps

Heat maps

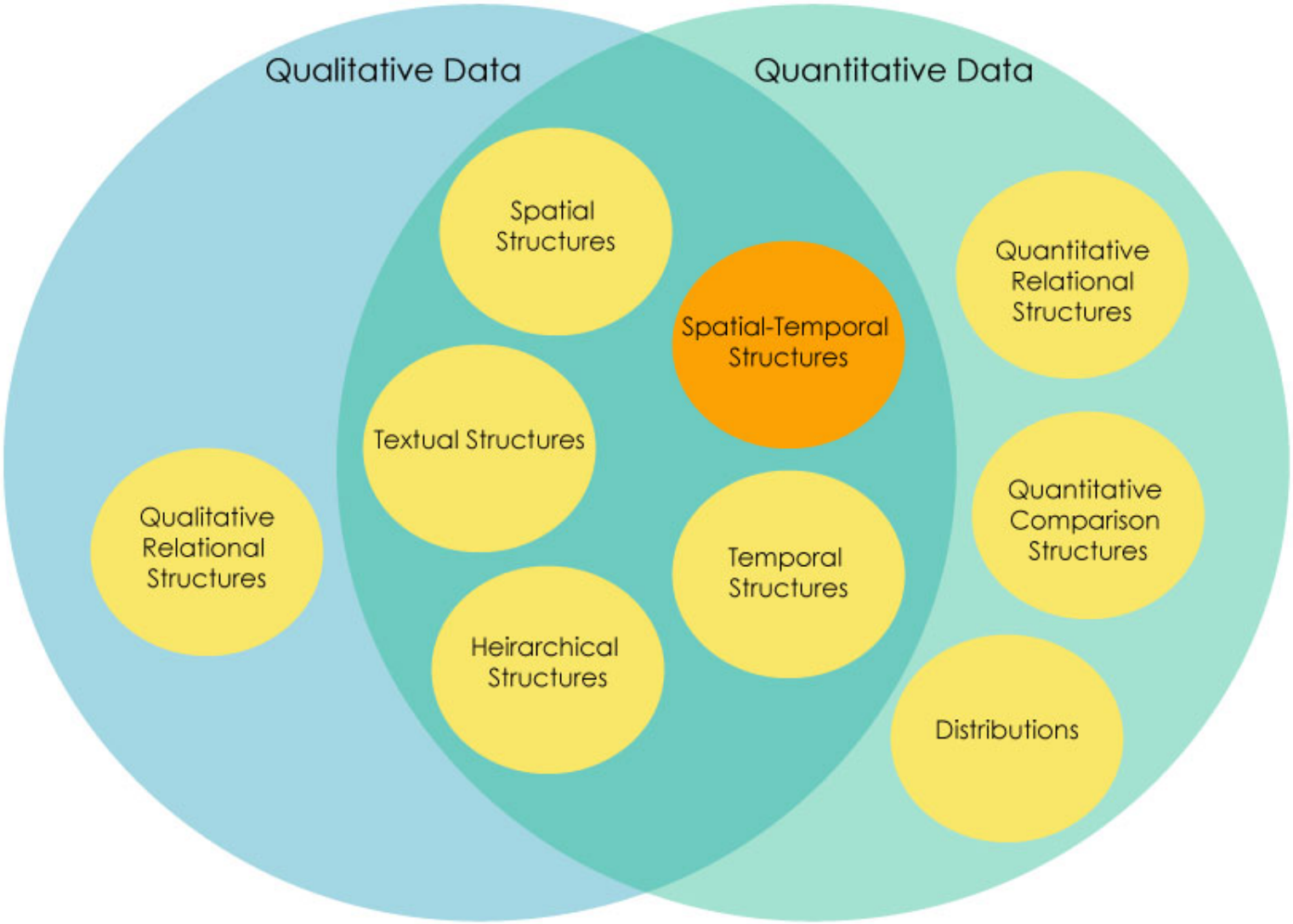


http://www.gislounge.com/heat-maps-in-gis/

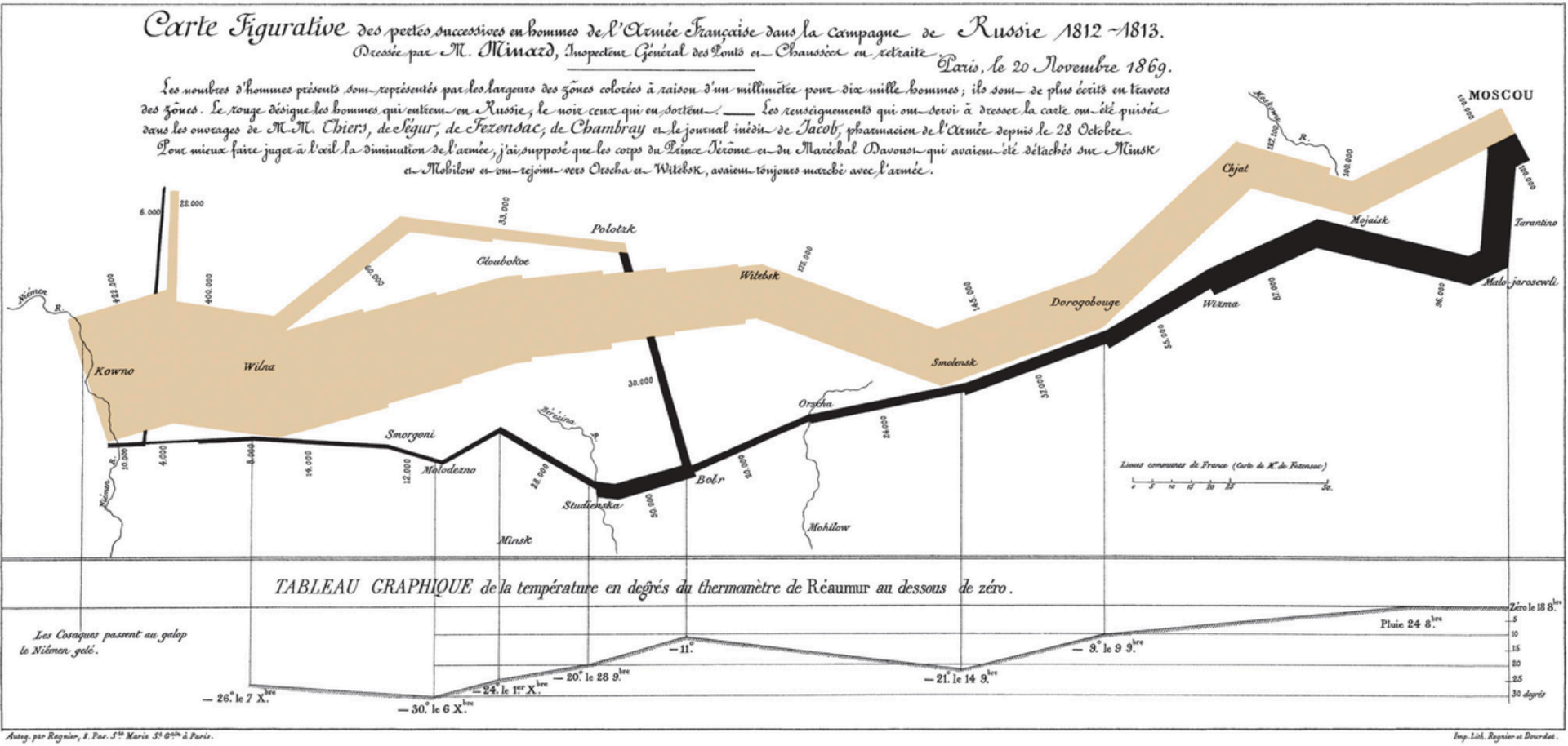
Spatial Structures: Maps



http://hint.fm/wind/


Qualitative Data
Quantitative Data
Spatial Structures
Spatial-Temporal Structures
Quantitative Relational Structures
Textual Structures
Qualitative Relational Structures
Quantitative Comparison Structures
Temporal Structures
Heirarchical Structures
Distributions

Spatial-Temporal Structures



Charles Minard's map of Napoleon's disastrous Russian campaign of 1812. The graphic is notable for its representation in two dimensions of six types of data: the number of Napoleon's troops; distance; temperature; the latitude and longitude; direction of travel; and location relative to specific dates

Spatial-Temporal Structures

Weather maps

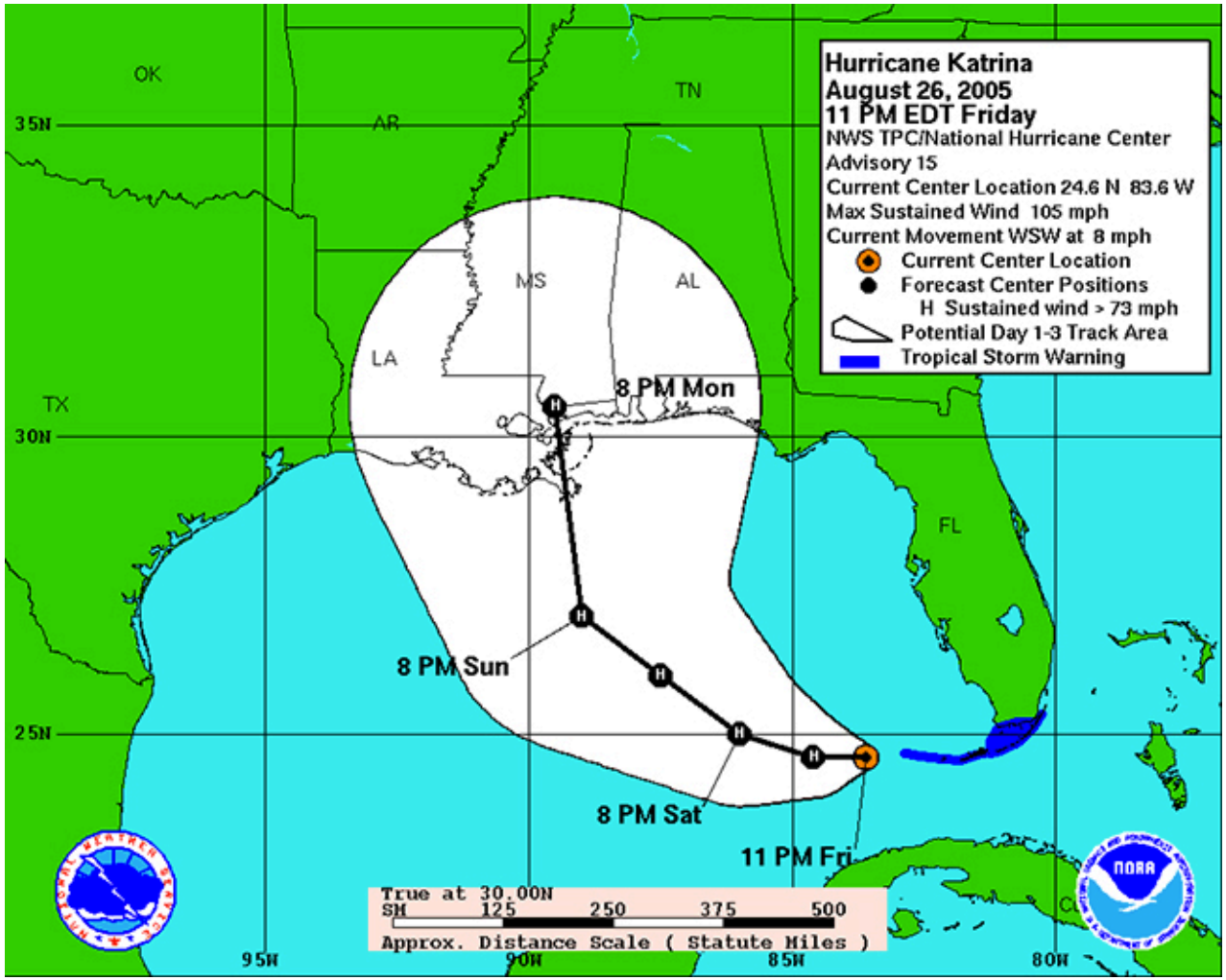
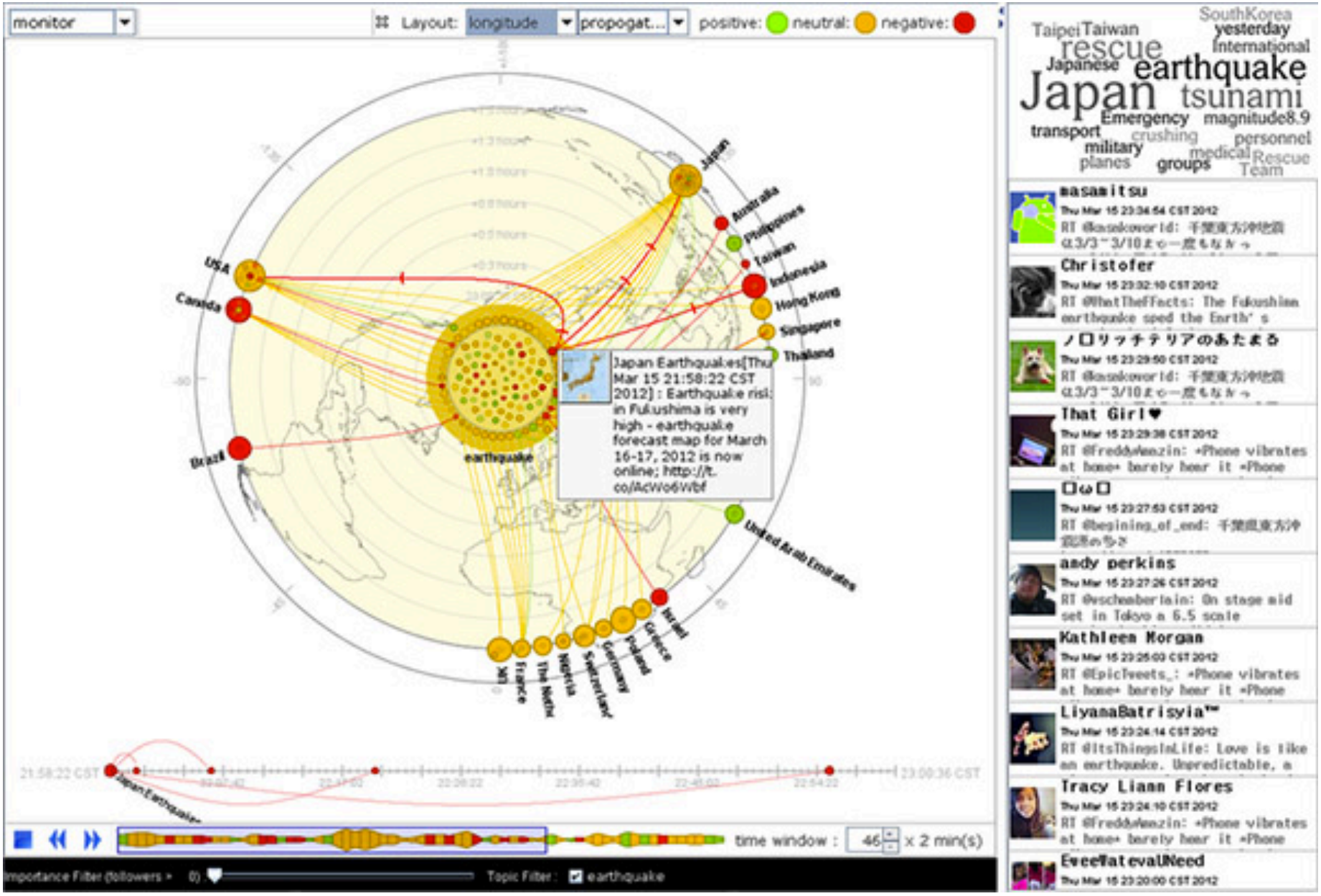


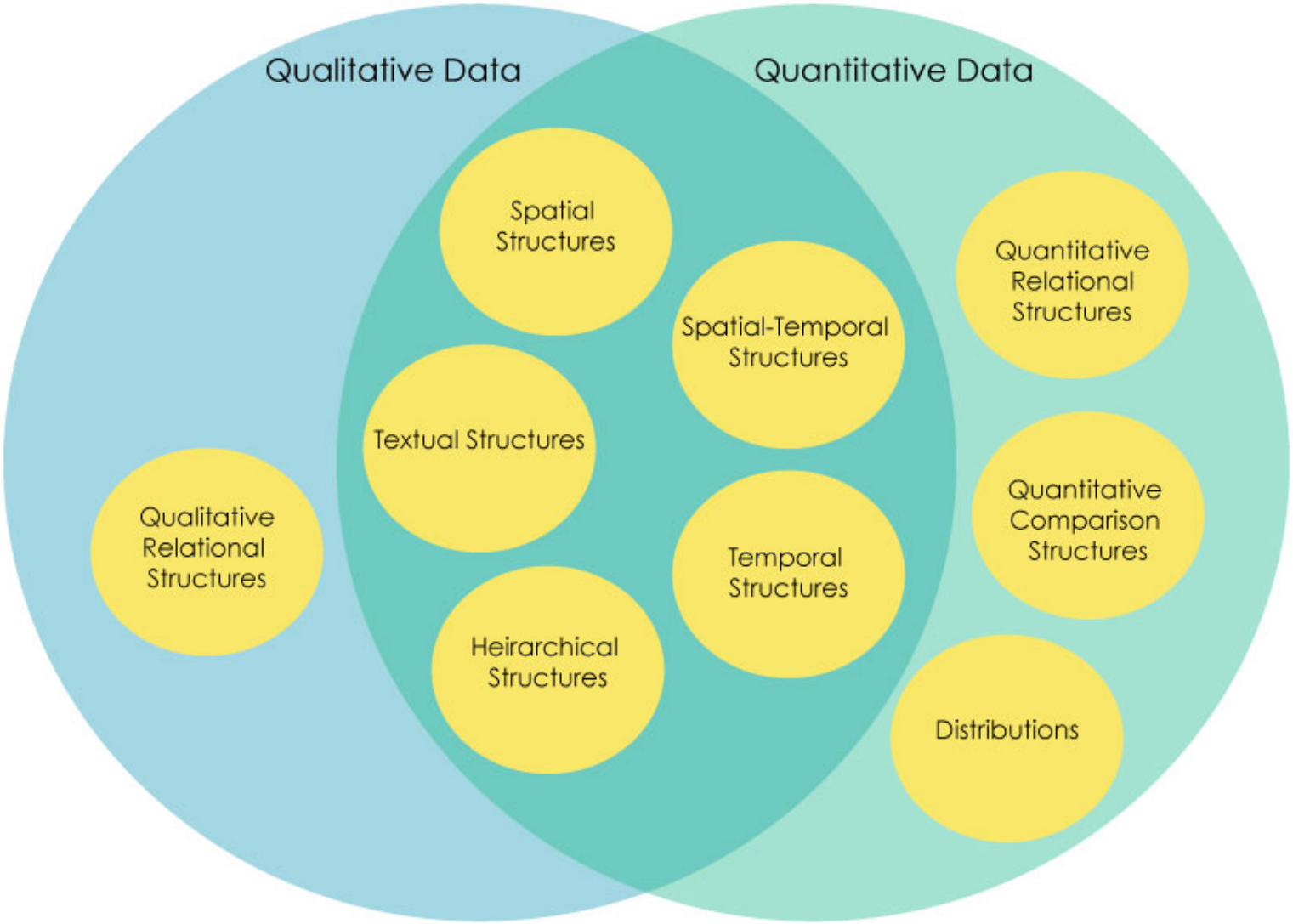
Image source:
http://www.weather.com/storms/hurricane/news/hurricane-katrina-forecast-shift-aug26-2005

Also See:
http://www.nytimes.com/interactive/2012/10/26/us/hurricane-sandy-map.html?_r=0

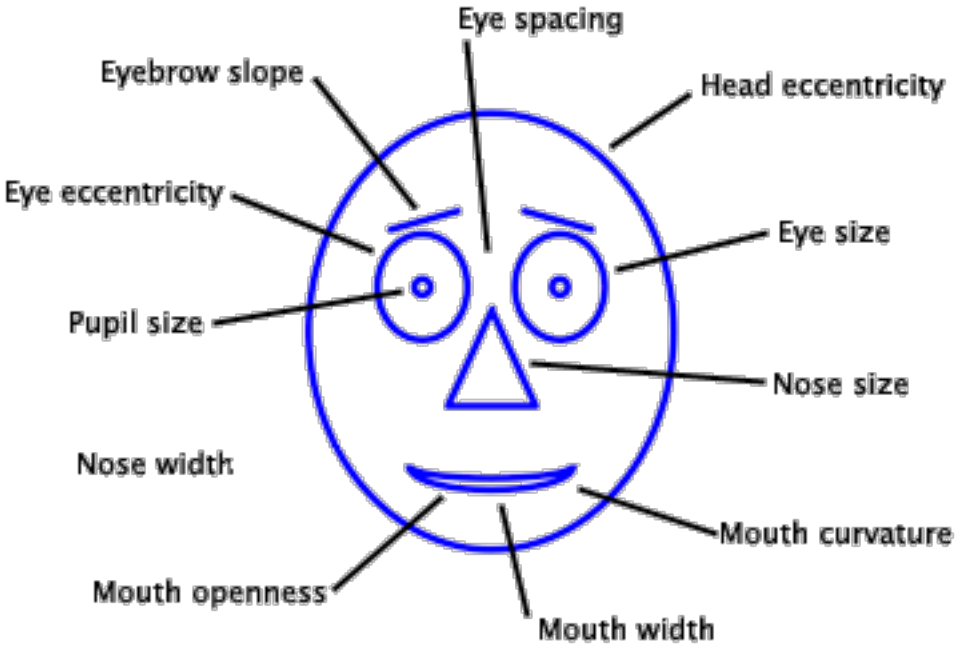
Spatial-Temporal Structures

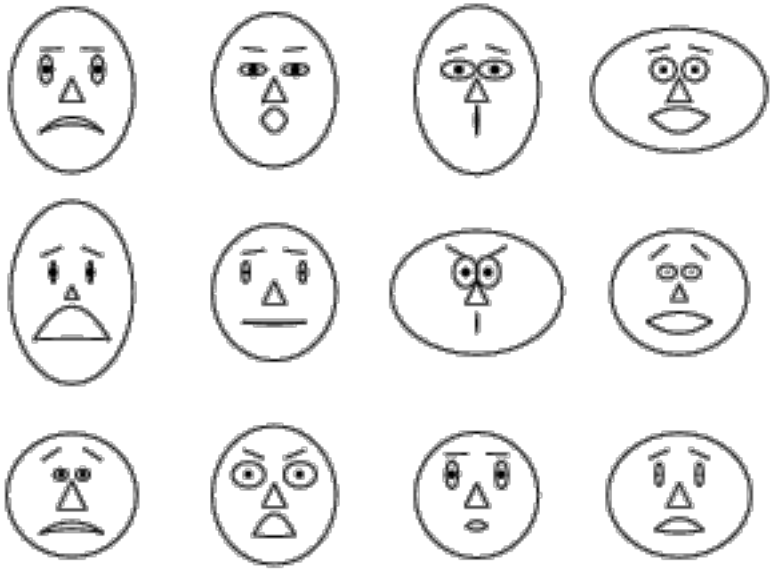


https://www.youtube.com/watch?v=ou8L0MzGvOU


Qualitative Data
Quantitative Data
Spatial Structures
Spatial-Temporal Structures
Quantitative Relational Structures
Textual Structures
Quantitative Comparison Structures
Qualitative Relational Structures
Temporal Structures
Heirarchical Structures
Distributions

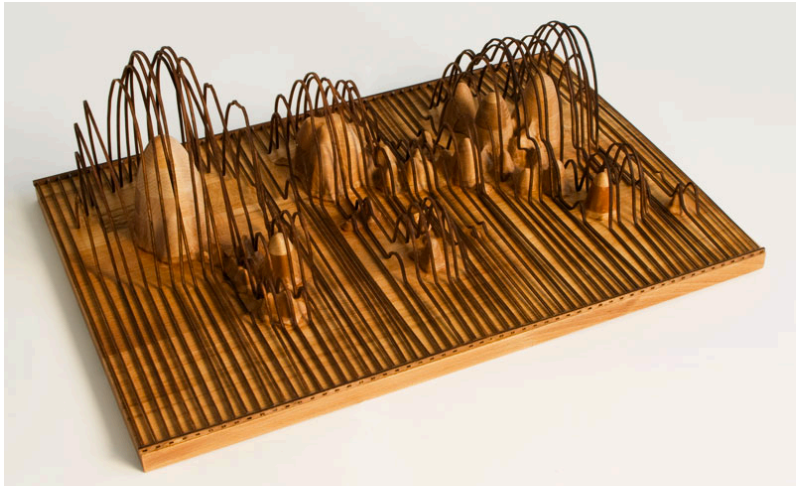
Other – Chernoff Faces





Beyond Visualizations

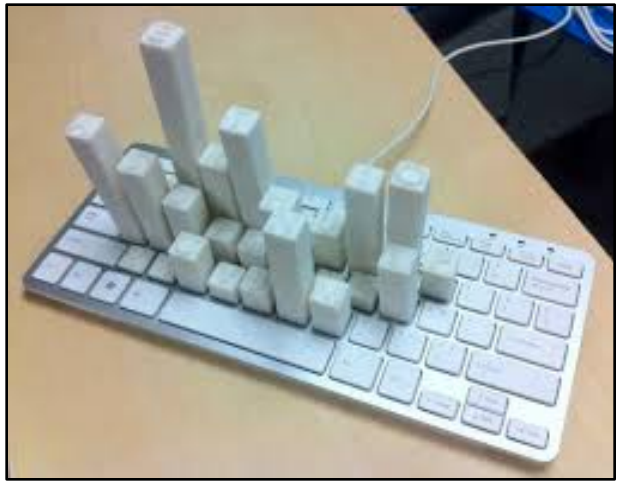
http://dataphys.org/list/tag/data-sculpture/
http://dataphys.org/list/



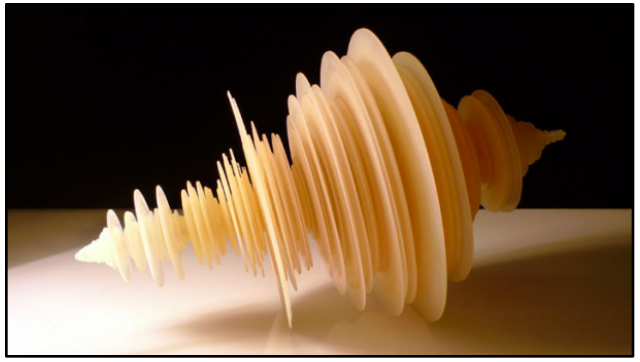
Fundament, Andreas Nicolas Fischer. 2008.
http://anf.nu/fundament/

http://dl.acm.org/citation.cfm?id=2481359

Jansen, Yvonne, Pierre Dragicevic, and Jean-Daniel Fekete. "Evaluating the efficiency of physical visualizations." Proceedings of the SIGCHI Conference on Human Factors in Computing Systems. ACM, 2013.



Keyboard frequency sculpture. Michael Knuepfel
aviz.fr/Research/PassivePhysicalVisualizations



Tokyo earthquake data sculpture. Luke Jerram
http://www.lukejerram.com/projects/t%C5%8Dhoku_earthquake