

Overview of InfoVis



CS 7450 - Information Visualization
Aug. 21, 2013
John Stasko

Exercise



- Get out pencil and paper



Data Explosion



- Society is more complex
 - There simply is more “stuff”



- Computers, internet and web give people access to an incredible amount of data
 - news, sports, financial, purchases, etc...

How Much Data? (1)



- Estimated info added to digital universe each year will soon approach 1 ZB (zettabyte)*
 - 100000000000000000000 (10²¹) bytes
 - From: http://www.emc.com/digital_universe viewed December 8, 2008

*But only half that goes to my email inbox

How Much Data? (2)



- 6 million FedEx transactions per day
<http://www.fedex.com/us/about/today/companies/corporation/facts.html>
- Average of 98 million Visa credit-card transactions per day in 2005
<http://www.corporate.visa.com/md/nr/press278.jsp>
- Average of 5.4 petabytes of data crosses AT&T's network per day
<http://att.sbc.com/gen/investor-relations?pid=5711>
- Average of 610 to 1110 billion e-mails worldwide per year (based on estimates in 2000)
<http://www2.sims.berkeley.edu/research/projects/how-much-info/internet.html>

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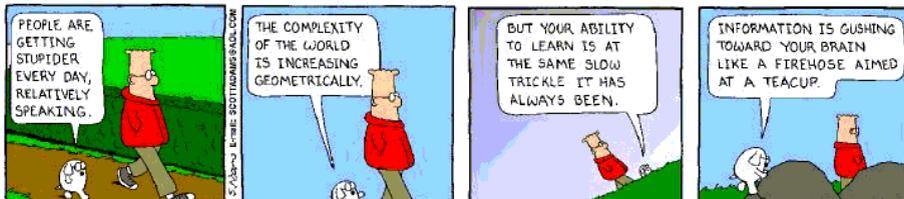
Slide courtesy Jim Thomas

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Data Overload



- Confound: How to make use of the data
 - How do we make sense of the data?
 - How do we harness this data in decision-making processes?
 - How do we avoid being overwhelmed?



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The Challenge



- Transform the *data* into *information* (understanding, insight) thus making it useful to people



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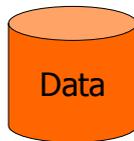
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The Problem



Web,
Books,
Papers,
Game scores,
Scientific data,
Biotech,
Shopping
People
Stock/finance
News



Data Transfer →

How?



Vision: 100 MB/s
Ears: <100 b/s
Telepathy
Haptic/tactile
Smell
Taste

Two slides courtesy
of Chris North

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Human Vision



- Highest bandwidth sense
- Fast, parallel
- Pattern recognition
- Pre-attentive
- Extends memory and cognitive capacity
(Multiplication test)
- People think visually

Impressive. Lets use it!

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An Example



- Why visualization helps...

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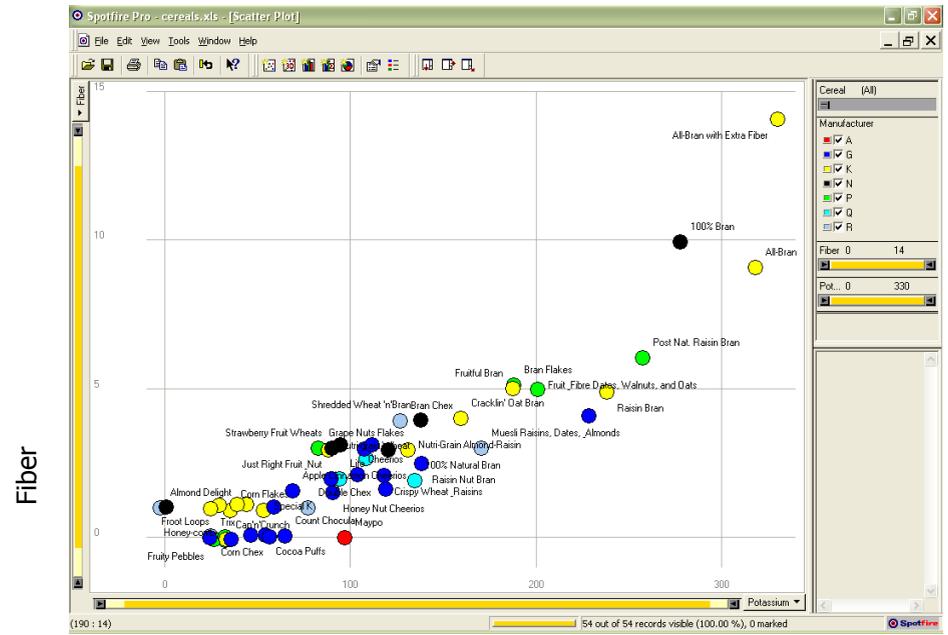
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Which cereal has the most/least potassium?
 Is there a relationship between potassium and fiber?
 If so, are there any outliers?
 Which manufacturer makes the healthiest cereals?



	A	B	C	D					
1	Cereal	Manufacturer	Fiber	Potassium					
2	100% Bran	N	10	280	28	Honey-comb	P	0	35
3	100% Natural Bran	Q	2	135	29	Just Right Fruit & Nut	K	2	95
4	All-Bran	K	9	320	30	Life	Q	2	95
5	All-Bran with Extra Fiber	K	14	330	31	Lucky Charms	G	0	55
6	Almond Delight	R	1	0	32	Maypo	A	0	95
7	Apple Cinnamon Cheerios	G	1.5	70	33	Muesli Raisins, Dates, &	R	3	170
8	Bran Chex	R	4	125	34	Multi-Grain Cheerios	G	2	90
9	Bran Flakes	P	5	190	35	Nutri-Grain Almond-Raisin	K	3	130
10	Cap'n Crunch	Q	0	35	36	Nutri-grain Wheat	K	3	90
11	Cheerios	G	2	105	37	Oatmeal Raisin Crisp	G	1.5	120
12	Cocoa Puffs	G	0	55	38	Post Nat. Raisin Bran	P	6	260
13	Corn Chex	R	0	25	39	Product 19	K	1	45
14	Corn Flakes	K	1	35	40	Quaker Oatmeal	Q	2.7	110
15	Count Chocula	G	0	65	41	Raisin Bran	K	5	240
16	Cracklin' Oat Bran	K	4	160	42	Raisin Nut Bran	G	2.5	140
17	Cream of Wheat (Quick)	N	1	0	43	Rice Krispies	K	0	35
18	Crispy Wheat & Raisins	G	2	120	44	Shredded Wheat	N	3	95
19	Double Chex	R	1	80	45	Shredded Wheat 'n Bran	N	4	140
20	Froot Loops	K	1	30	46	Shredded Wheat spoon	N	3	120
21	Frosted Flakes	K	1	25	47	Smacks	K	1	40
22	Fruit & Fibre Dates, Wal	P	5	200	48	Special K	K	1	55
23	Fruitful Bran	K	5	190	49	Strawberry Fruit Wheats	N	3	90
24	Fruity Pebbles	P	0	25	50	Total Corn Flakes	G	0	35
25	Golden Grahams	G	0	45	51	Total Raisin Bran	G	4	230
26	Grape Nuts Flakes	P	3	85	52	Total Whole Grain	G	3	110
27	Honey Nut Cheerios	G	1.5	90	53	Trix	G	0	25
					54	Wheaties	G	3	110
					55	Wheaties Honey Gold	G	1	60



Even Tougher?



- What if you could only see one cereal's data at a time? (e.g. some websites)
- What if I read the data to you?

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More on this Topic



- "Value of visualization" day next week

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Exercise Redux



- Let's check what you did...

- People work differently

Visualization



- Definition
 - “The use of computer-supported, interactive visual representations of data to amplify cognition.”
From [Card, Mackinlay Shneiderman '98]

Visualization



- Often thought of as process of making a graphic or an image
- Really is a cognitive process
 - Form a mental image of something
 - Internalize an understanding
- “The purpose of visualization is insight, not pictures”
 - Insight: discovery, decision making, explanation

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Main Idea



- Visuals help us think
 - Provide a frame of reference, a temporary storage area
- Cognition → Perception
- Pattern matching
- External cognition aid
 - Role of external world in thinking and reason

Larkin & Simon '87

Card, Mackinlay, Shneiderman '98

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Expressed Well



“Contained within the data of any investigation is information that can yield conclusions to questions not even originally asked. That is, there can be surprises in the data...To regularly miss surprises by failing to probe thoroughly with visualization tools is terribly inefficient because the cost of intensive data analysis is typically very small compared with the cost of data collection.”

W. Cleveland
The Elements of Graphing Data

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Part of our Culture



- “I see what you’re saying”
- “Seeing is believing”
- “A picture is worth a thousand words”

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Purpose



- Two main uses of infovis
 - Analysis – Understand your data better and act upon that understanding
 - Presentation – Communicate and inform others more effectively

1. Analysis



- Given all the data, then
 - understand, compare, decide, judge, evaluate, assess, determine, ...
- Ultimately, about solving problems

When to Apply?



- Many other techniques for data analysis
 - Statistics, DB, data mining, machine learning
- Visualization most useful in **exploratory data analysis**
 - Don't know what you're looking for
 - Don't have a priori questions
 - Want to know what questions to ask

"A graphic display has many purposes but it achieves its highest value when it forces us to see what we were not expecting."

H. Wainer

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EDA Example 1



- Business
 - Why has Hyundai made such great strides in the US market?
 - How influential was their "Lose your job, we'll buy the car back" campaign?
 - Have their cars improved in quality? If so, in what major ways?
 - Is the Genesis as good of a car as the Lexus ES?

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EDA Example 2



- Airlines
 - What are the key factors causing flight delays in the US?
 - Are delays worse in the summer or winter?
 - Is the seasonal effect influenced by geographic location?
 - How does competition at an airport affect flight delays?

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More on EDA



“Information visualization is ideal for exploratory data analysis. Our eyes are naturally drawn to trends, patterns, and exceptions that would be difficult or impossible to find using more traditional approaches, such as tables or text, including pivot tables. When exploring data, even the best statisticians often set their calculations aside for a while and let their eyes take the lead.”

S. Few
Now you see it

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Tasks for Info Vis?



- Search (OK)
 - Finding a specific piece of information
 - How many games did the Braves win in 1995?
 - What novels did Ian Fleming author?
- Browsing (Better)
 - Look over or inspect something in a more casual manner, seek interesting information
 - Learn about crystallography
 - What has Jane been up to lately?

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Tasks in Info Vis



- Analysis
 - Comparison-Difference
 - Outliers, Extremes
 - Patterns
- Assimilation
- Monitoring
- Awareness

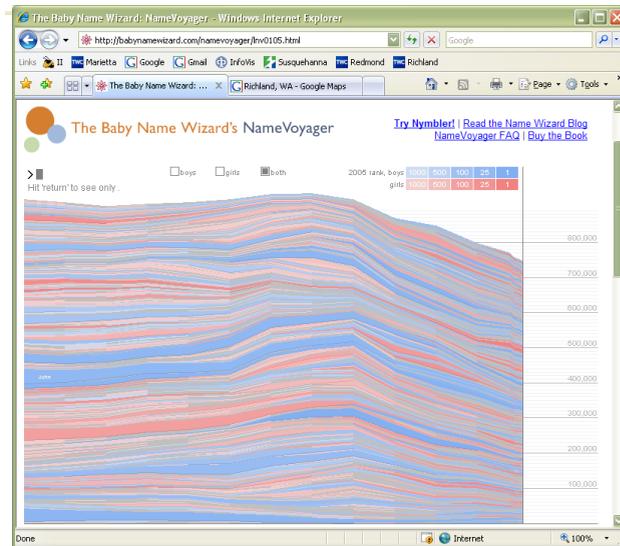
More to come in a future class...

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Baby Name Wizard



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2. Presentation

- Use visualization to communicate ideas, influence, explain, persuade
- Visuals can serve as evidence or support

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When to Apply?



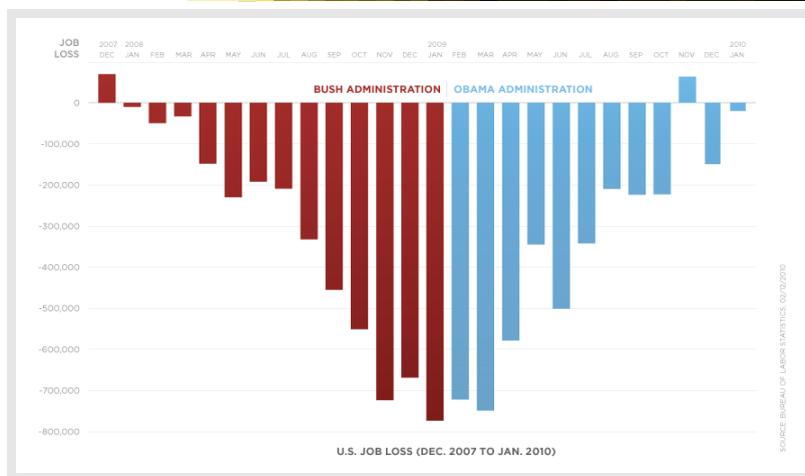
- Visuals can frequently take the place of many words
- Visuals can summarize, aggregate, unite, explain, ...
- Sometimes words are needed, however

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Job Losses



Controversial, see <http://soquelbythecreek.blogspot.com/2010/02/what-does-obama-job-chart-really-mean.html>

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Key Benefits of Visualization



- Facilitating awareness and understanding
- Helping to raise new questions and supply answers
- Generating insights
- Telling a story and making a point

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Key Challenge

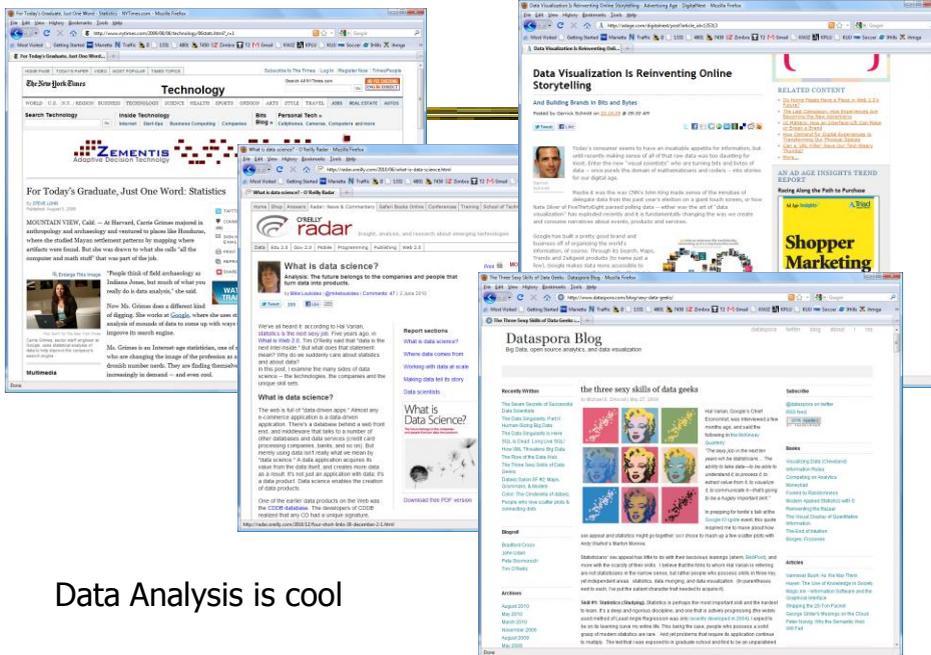


- How to measure and prove?
 - All those benefits are not easily quantifiable and measured
- Evaluation is perhaps primary open research challenge for visualization

More to come later in term

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Data Analysis is cool

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Academic Areas



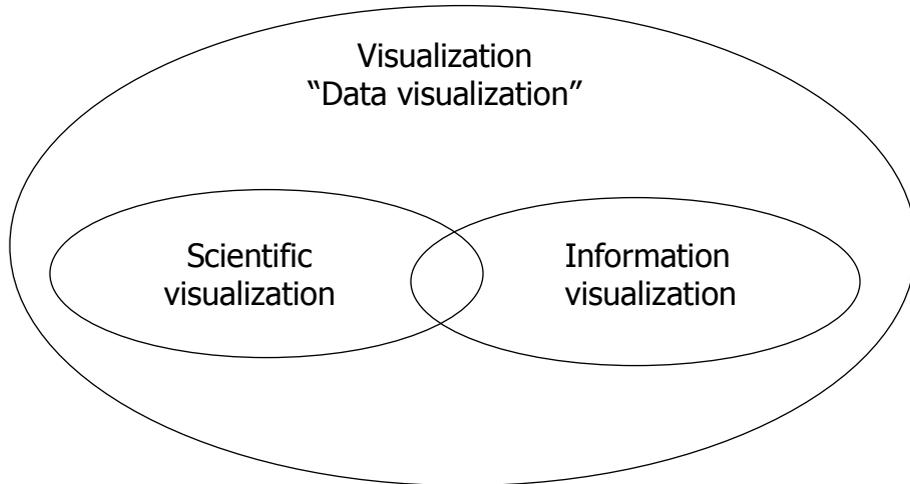
- Where does InfoVis fit in the academic world?

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Overview



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Scientific Visualization



- Primarily relates to and represents something physical or geometric
 - Often 3-D
 - Examples
 - Air flow over a wing
 - Stresses on a girder
 - Torrents inside a tornado
 - Organs in the human body
 - Molecular bonding

Not the focus of this class

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Information Visualization



- 1. What is “information”?
 - Items, entities, things which do not have a direct physical correspondence
 - Notion of abstractness of the entities is important too
 - Examples: baseball statistics, stock trends, connections between criminals, car attributes...

Information Visualization



- 2. What is “visualization”?
 - The use of computer-supported, interactive visual representations of data to amplify cognition.
 - From [Card, Mackinlay Shneiderman '98]

Information Visualization



- Characteristics:
 - Taking items without a direct physical correspondence and mapping them to a 2-D or 3-D physical space.
 - Giving information a visual representation that is useful for analysis and presentation
 - “A key challenge in information visualization is designing a cognitively useful spatial mapping of a dataset that is not inherently spatial and accompanying the mapping by interaction techniques that allow people to intuitively explore the dataset. Information visualization draws on the intellectual history of several traditions, including computer graphics, human-computer interaction, cognitive psychology, semiotics, graphic design, statistical graphics, cartography, and art.”

<http://conferences.computer.org/infovis/>

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Constituents



- Two key aspects of infovis
 - Representation
 - Interaction (too often overlooked)

“The effectiveness of information visualization hinges on two things: its ability to clearly and accurately represent information and our ability to interact with it to figure out what the information means.”

S. Few, Now you see it

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Two Key Challenges



- Scale
 - Challenge often arises when data sets become large
- Diversity
 - Data of data types, forms, sizes

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Example Domains for Info Vis



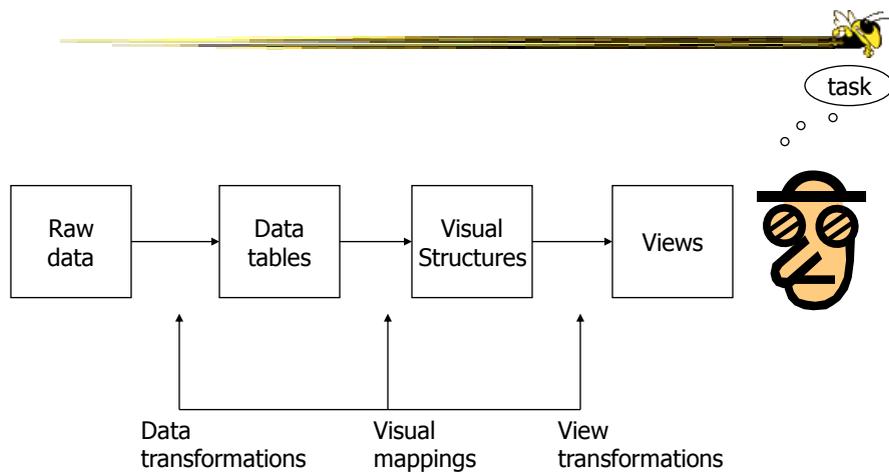
- Text
- Statistics
- Financial/business data
- Internet information
- Software
- ...

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InfoVis Process Model



From: Card, Mackinlay, Shneiderman '99

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Alternate Model

Acquire → Parse → Filter → Mine → Represent → Refine → Interact

From: Fry '02

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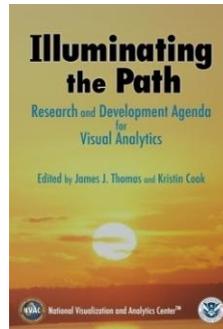
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New Area Emerging: Visual Analytics



Visual analytics is the science of analytical reasoning facilitated by interactive visual interfaces



Available at <http://nvac.pnl.gov/>
in PDF form

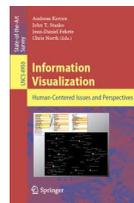
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Alternate Definition



Visual analytics combines automated analysis techniques with interactive visualizations for an effective understanding, reasoning and decision making on the basis of very large and complex data sets

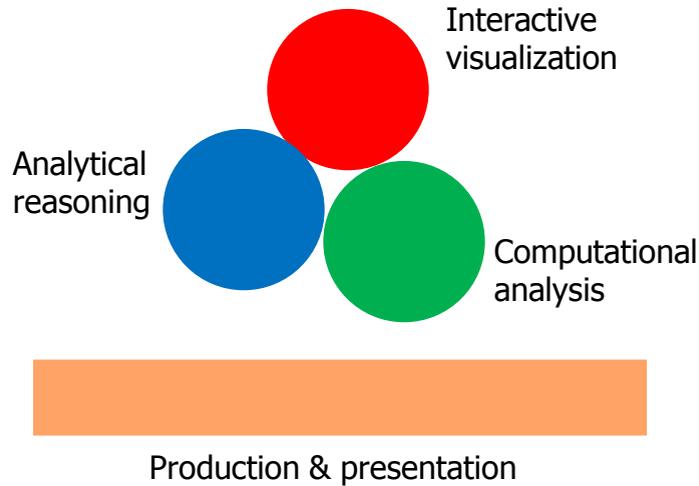


Keim et al
chapter in *Information Visualization: Human-Centered Issues and Perspectives*, 2008

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Main Components



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Back to InfoVis (Examples)



- Start with static pictures (InfoGraphics)
 - Very popular on the web
 - But are they information visualizations?

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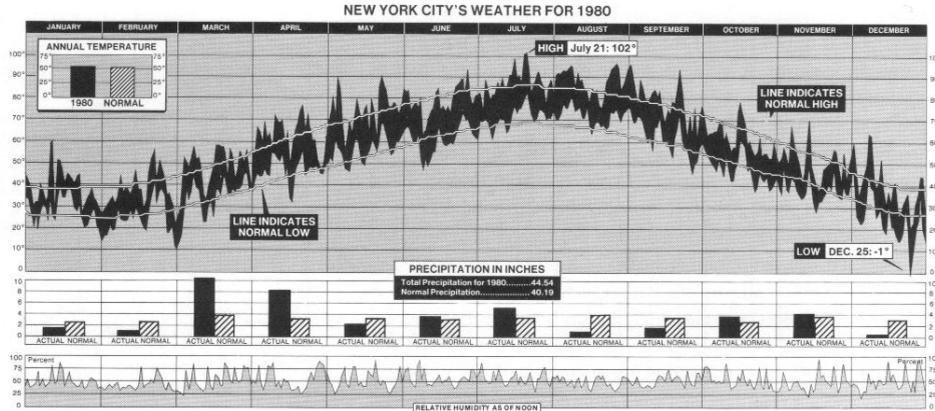
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NYC Weather



2220 numbers



New York Times, January 11, 1981, p. 32.

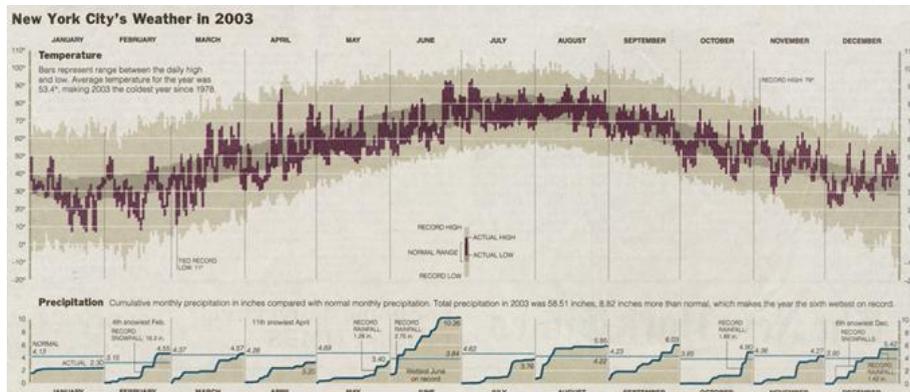
Tufte, Vol. 1

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Updated Version



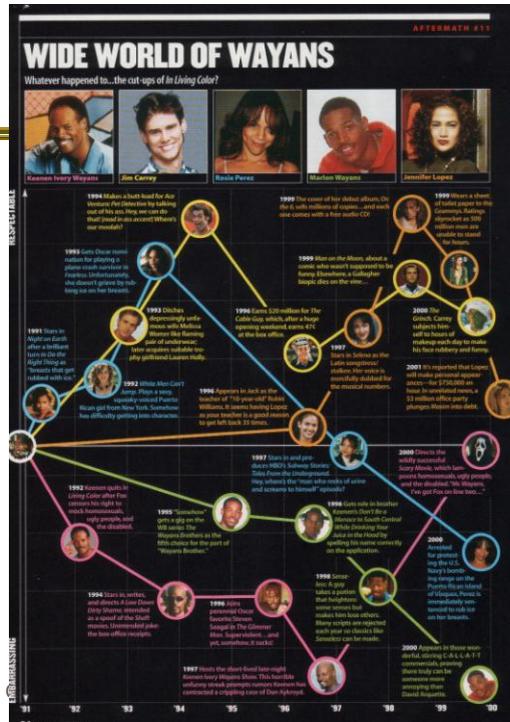
http://www.edwardtufte.com/bboard/q-and-a-fetch-msg?msg_id=00014g

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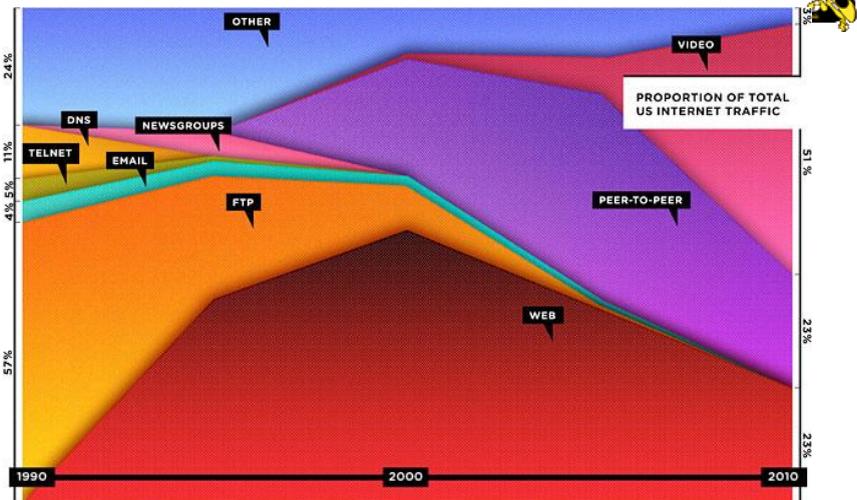
In Living Color



Maxim Magazine, July '01

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Internet Traffic



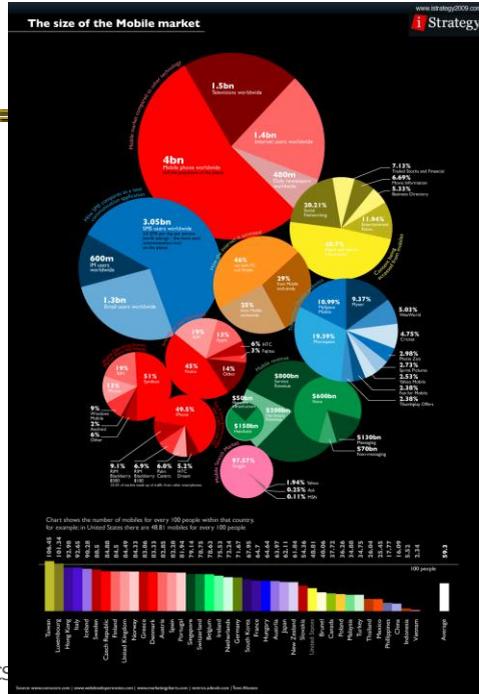
http://www.wired.com/magazine/2010/08/ff_webrip/all/1

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Mobile Market



<http://tecverse.com/design/cellphone-penetration-worldwide.html>

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Soccer

CO Thursday, June 7, 2012

SOCCER

South China Morning Post

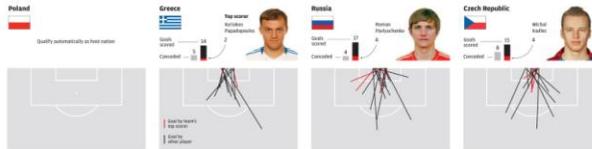


All of the goals which took the teams to Euro 2012

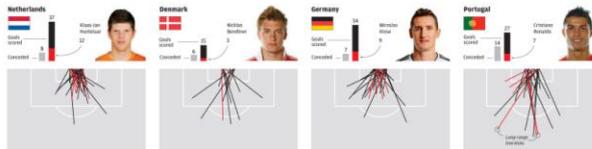
Euro 2012 kick-off tomorrow night and promises to keep soccer fans glued to their screens and for the rest of the month. The Post takes a look at how the 16 finalists got the ball in the back of the net to qualify, giving an idea of who is most likely to be a scoring threat in the finals, and from where.

Simon Scarr
South China Morning Post

Group A



Group B



<http://www.visualisingdata.com/blog/wp-content/uploads/2013/04/GOALS.jpg>

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Beer

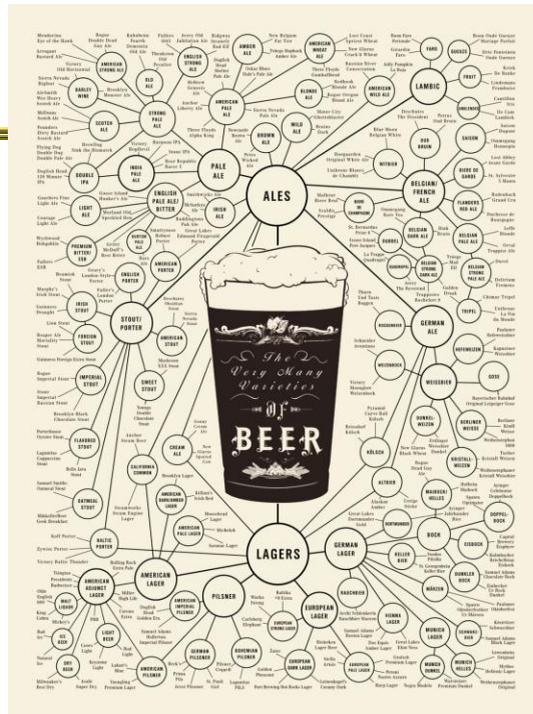


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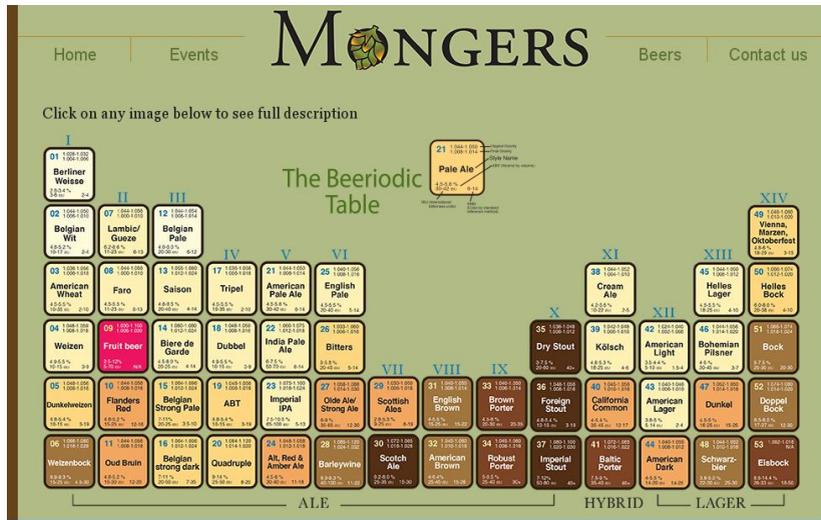
Beer!



http://images.fastcompany.com/upload/poster_beer_1300.jpg

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More Beer!



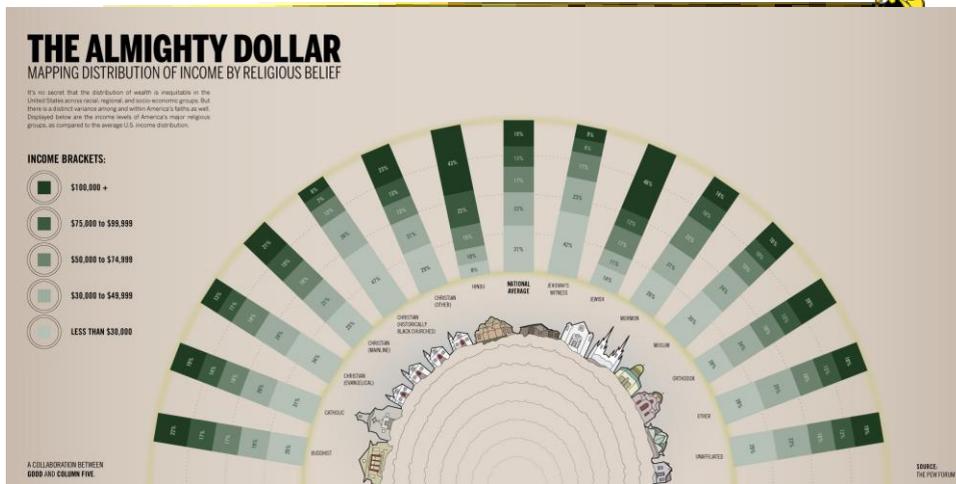
<http://thebeermongers.com/beers/>

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Income and Religion



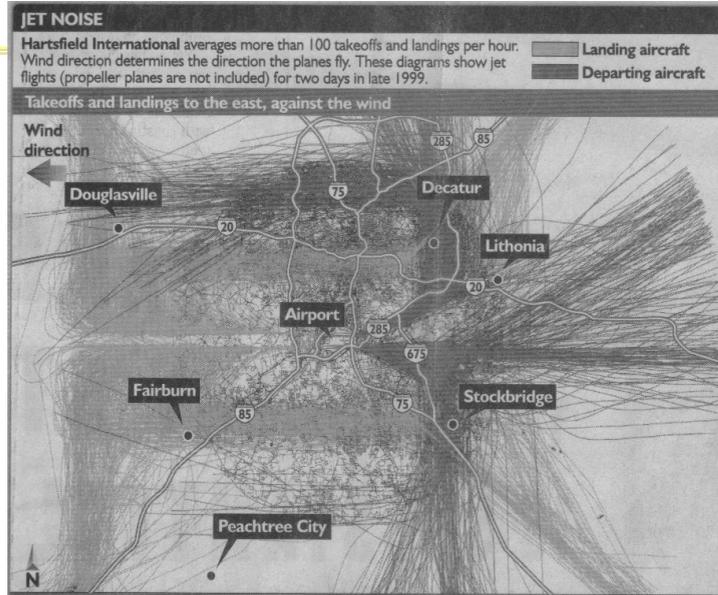
<http://awesome.good.is/transparency/web/1002/almighty-dollar/transparency.jpg>

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Atlanta Flight Traffic



Atlanta Journal
April 30, 2000

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Country Music



Figure 14. States Mentioned in Country-Music Lyrics
Source: Ben Marsh, "A Rose-Colored Map," *Harper's*, July 1977, 80. Used by permission.
Note: The size of each state is proportional to the number of times it is mentioned.

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Easy Walking Lines Added



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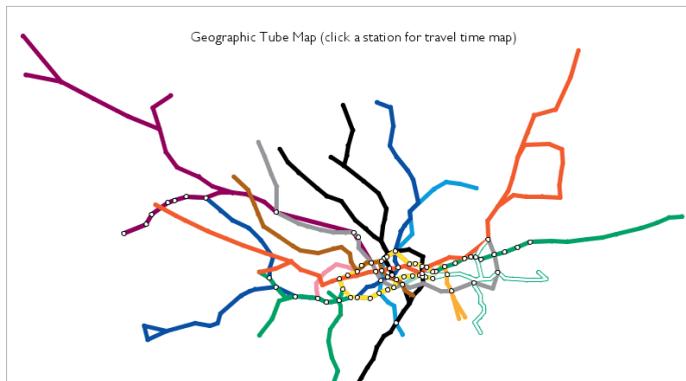
Travel Help



Travel Time Tube Map

Geographic Layout

Click on (or select, above) a station to see the London Underground map reorganise around the times of travel from that station. Shortest paths are used to place the other stations - radius is proportional to time to travel, and angle should be correct for as-the-crow-flies direction on a map. The concentric circles are at 10 minute intervals. Press 'g' to get back to the geographical tube map.



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Interaction

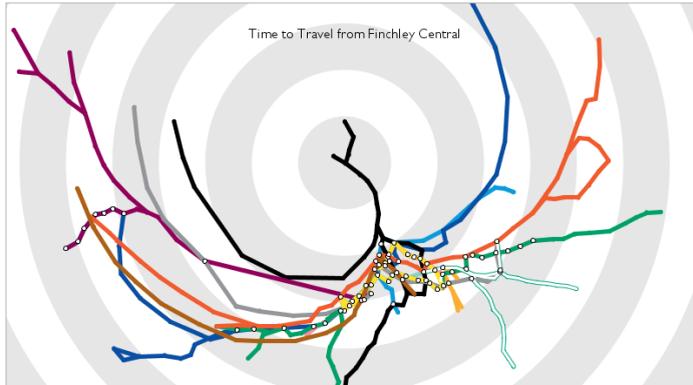
Shows travel times



Travel Time Tube Map

Gallions Reach

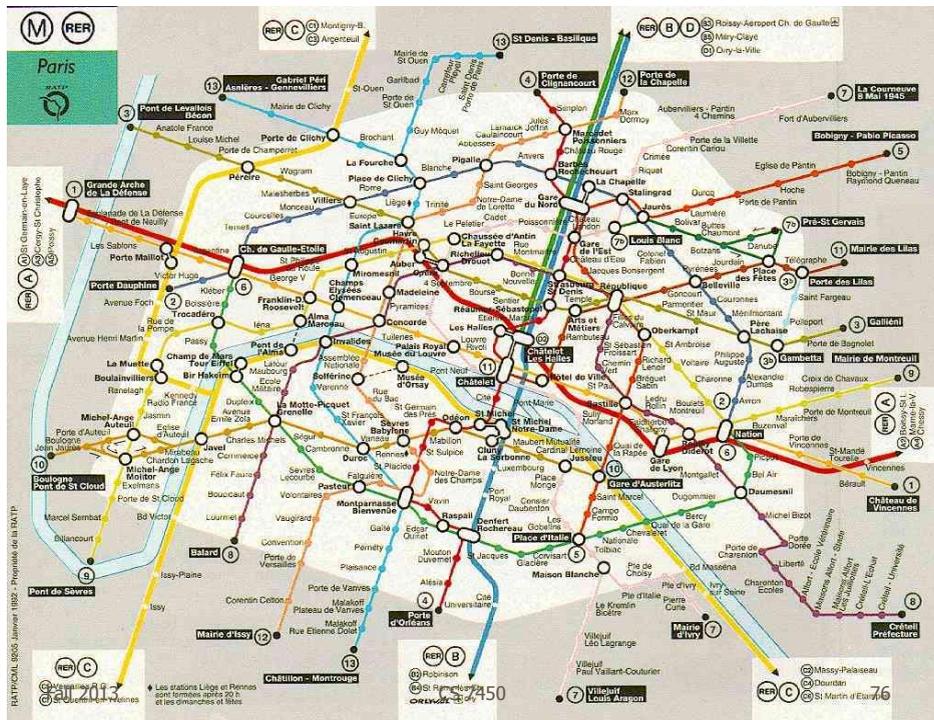
Click on (or select, above) a station to see the London Underground map reorganise around the times of travel from that station. Shortest paths are used to place the other stations - radius is proportional to time to travel, and angle should be correct for as-the-crow-flies direction on a map. The concentric circles are at 10 minute intervals. Press 'g' to get back to the geographical tube map.



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Atlanta MARTA

They have rivers,
we have highways
:^(



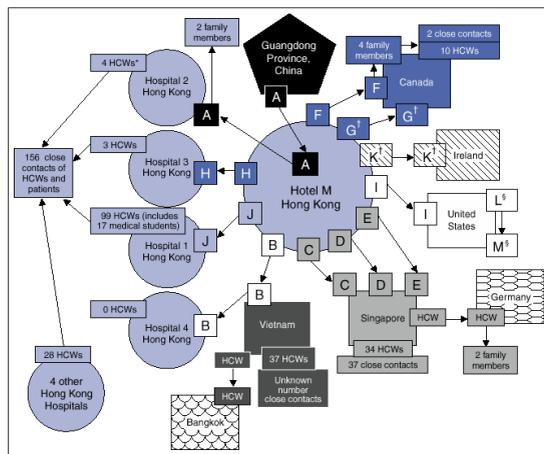
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www.cdc.gov/mmwr/preview/mmwrhtml/mm5212a1.htm

SARS Outbreak



FIGURE 1. Chain of transmission among guests at Hotel M — Hong Kong, 2003



[†]Health-care workers.
[‡]All guests except G and K stayed on the 9th floor of the hotel. Guest G stayed on the 14th floor, and Guest K stayed on the 11th floor.
[§]Guests L and M (spouse) were not at Hotel M during the same time as index Guest A but were at the hotel during the same time as Guests G, H, and I, who were ill during this period.

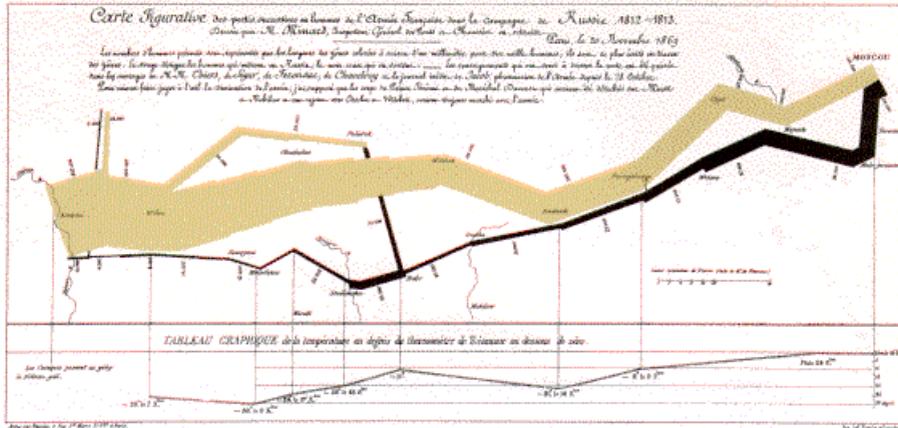
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Napoleon's March

From E. Tufte
*The Visual Display of
 Quantitative Information*



Minard graphic	size of army direction	latitude longitude	temperature date
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Or, for fun...



http://infosthetics.com/archives/2008/09/funniest_pie_chart_ever.html

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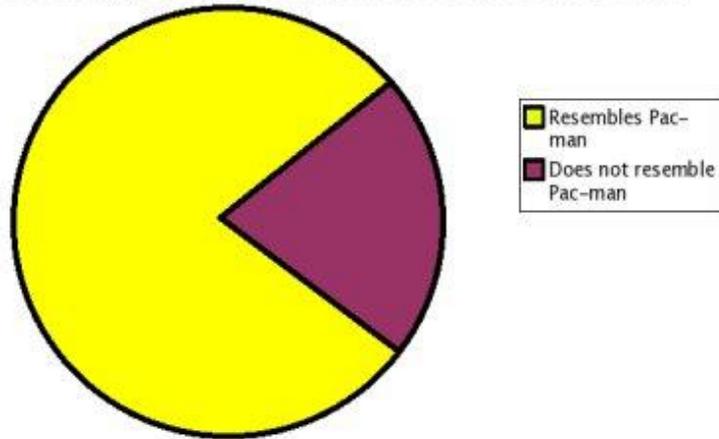
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Percentage of Chart Which Resembles Pac-man

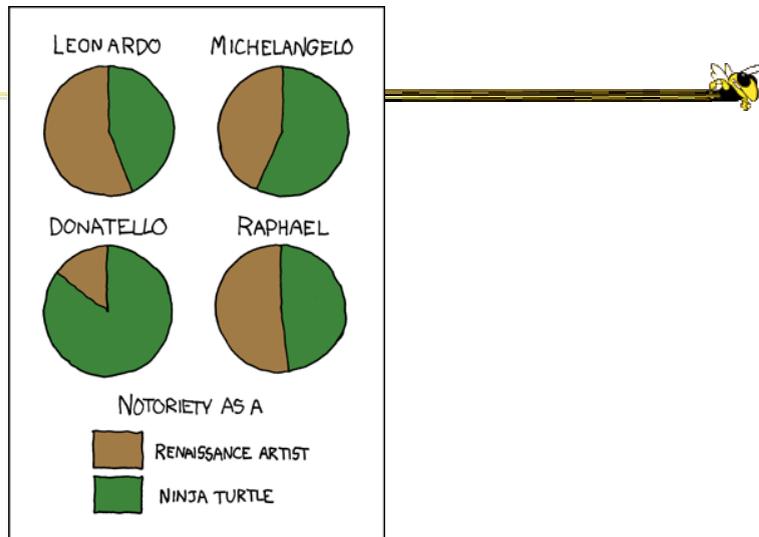


<http://www.boingboing.net/2006/11/02/hilarious-piechartvi.html>

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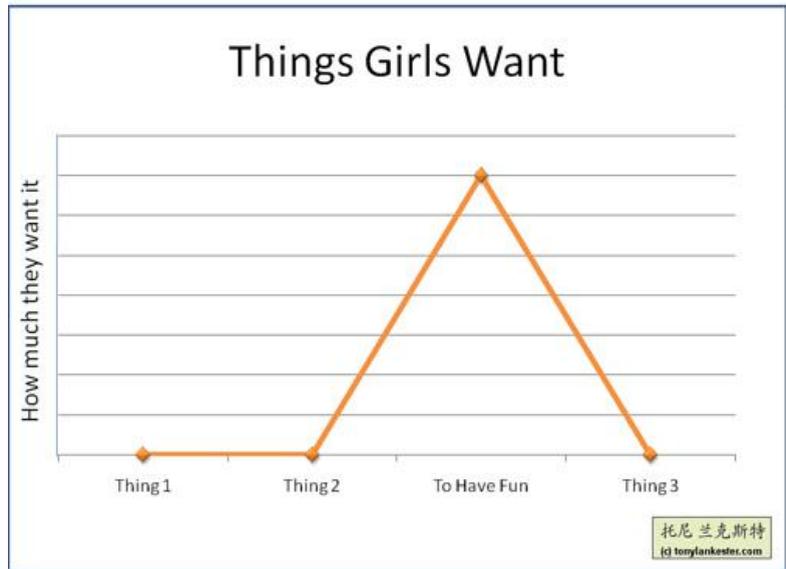


<http://xkcd.com/197/>

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<http://www.flickr.com/photos/91884218@N00/3108768440/in/pool-songchart>

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But Don't Do This

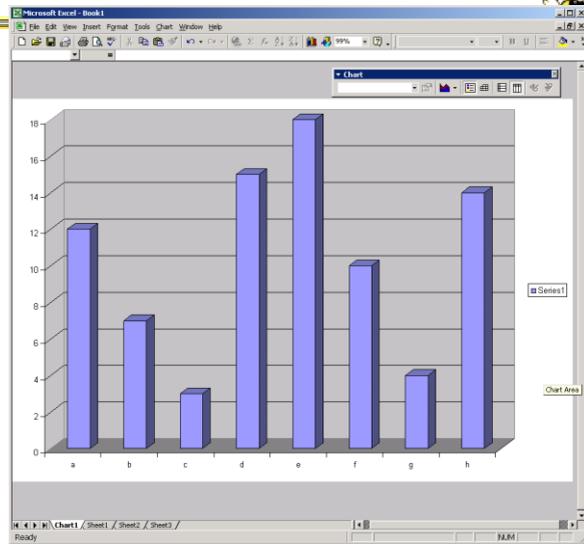
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Excel

Get rid of those darn 3D bars!



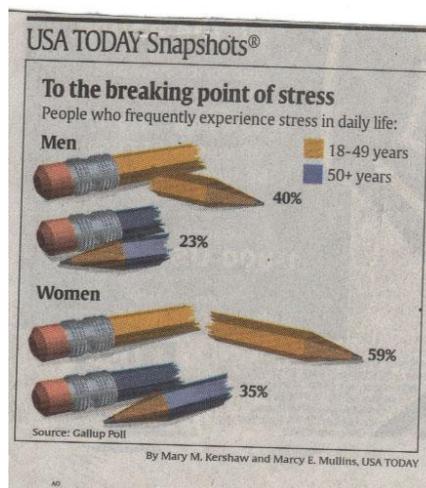
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USA Today Graphics

Or worse yet...



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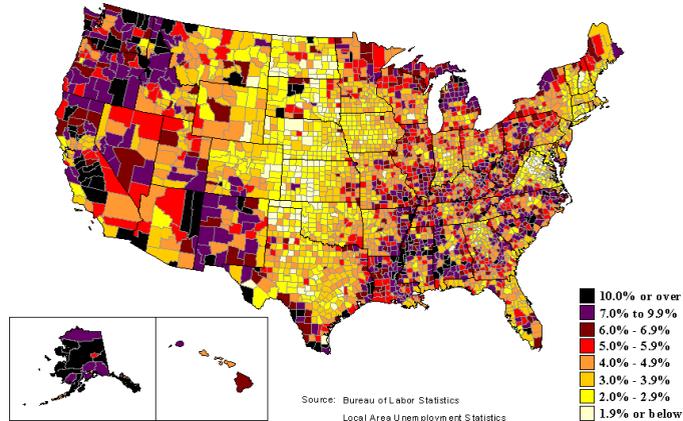
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Unemployment Rates



Unemployment rates by county,
December 2000 - November 2001 averages
(U.S. rate = 4.6 percent)

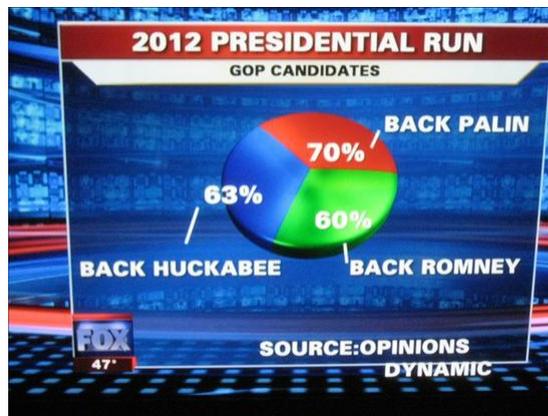


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FOX "News"



<http://wonkette.com/412361/all-193-of-republicans-support-palin-romney-and-huckabee>

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Examples



- Tools/Systems
 - Now interaction becomes important...

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HomeFinder



HCIL
Univ. Maryland

Dynamic HomeFinder

Reset Quit
Save Print

Dist to A: 30
1 30

Dist to B: 30
1 30

Bedrooms: 7
1 7

Cost: \$50k \$500k
1 500k 500k

Look at:
Hse TH Cnd

Features:
Gr9 Fp1
CAC New

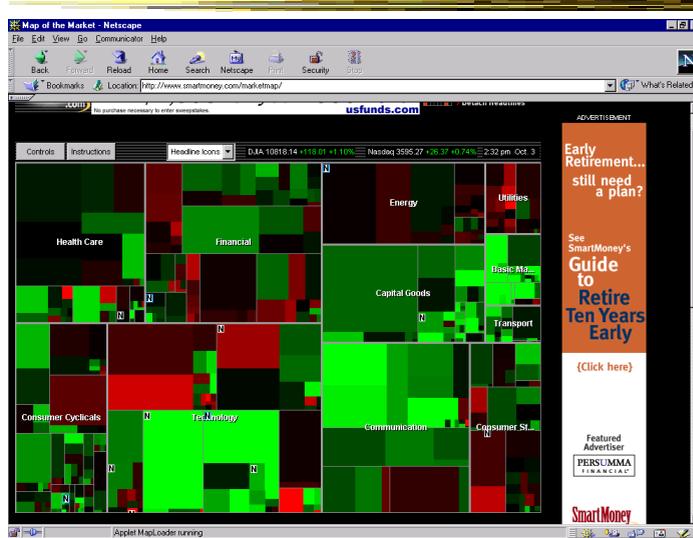
The yellow dots above are homes in the DC area for sale. You may get more information on a home by selecting it. You may drag the 'A' and 'B' distance markers to your office or any other location you want to live near. Select distances, bedrooms, and cost ranges by dragging the corresponding slider boxes on the right. Select specific home types and services by pressing the labeled buttons on the right.

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Map of the Market



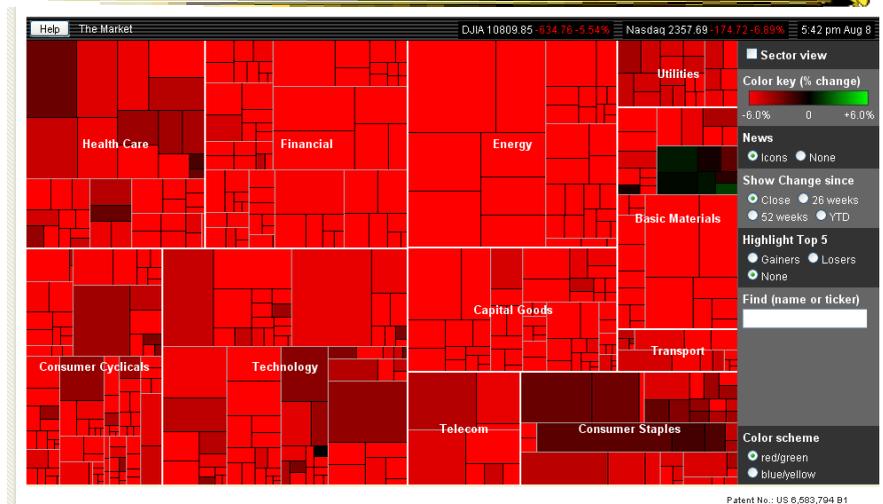
Demo

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Some Days It Looks Like This...



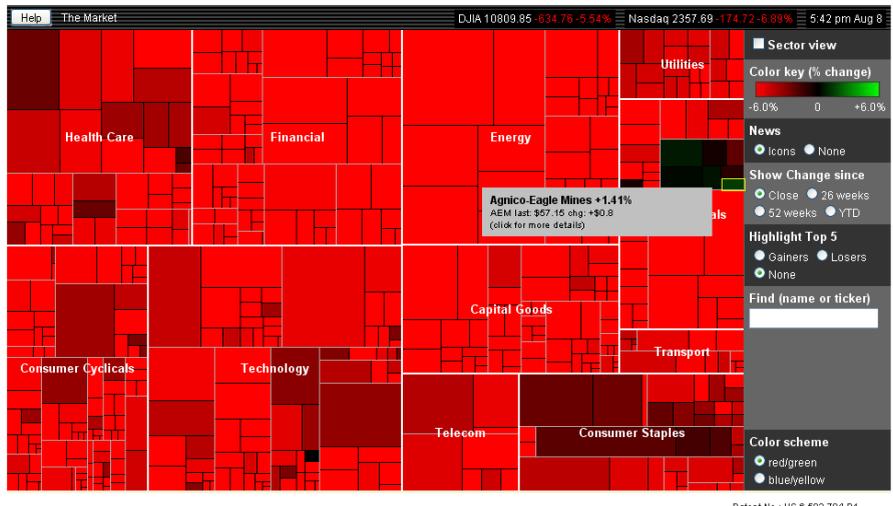
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Aug. 8, 2011

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Some Days It Looks Like This...



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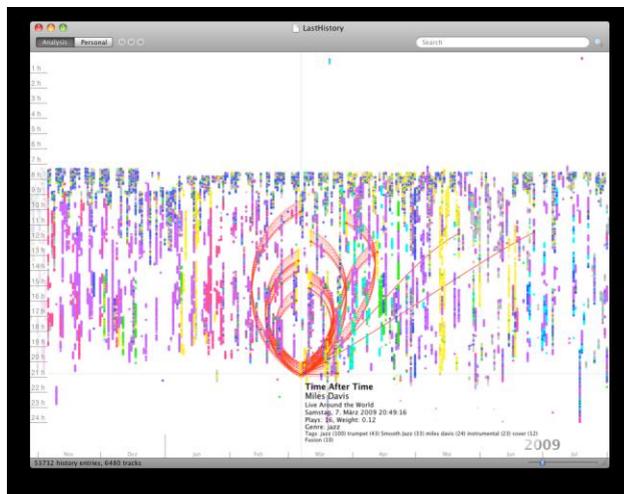
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Aug. 8, 2011

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<http://www.frederikseiffert.de/lasthistory/>

Your Music Listening History



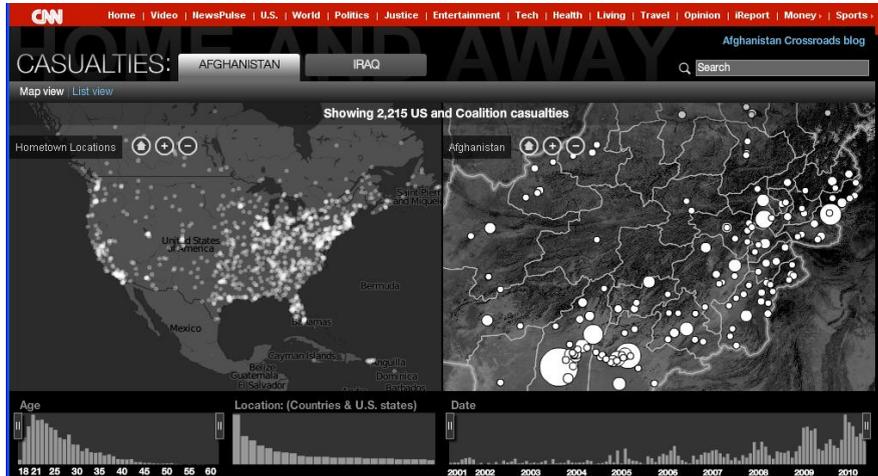
Video

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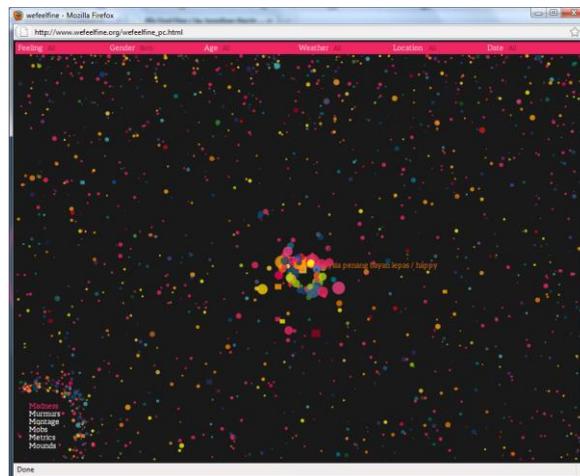
Casualties of War



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IM/Tweets



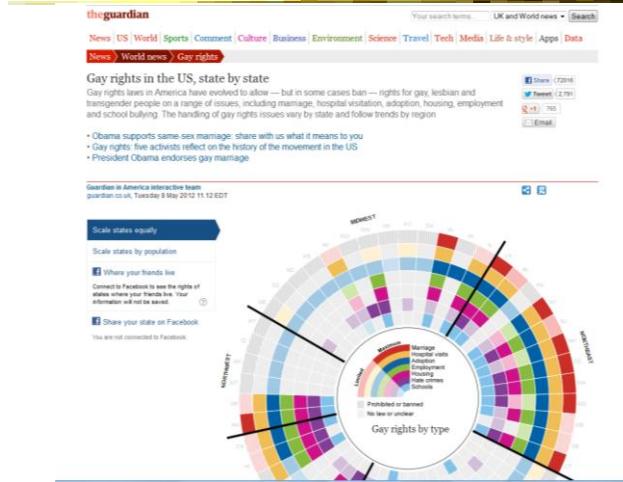
http://www.wefeelfine.org

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Gay Rights in the US



<http://www.guardian.co.uk/world/interactive/2012/may/08/gay-rights-united-states?fb=ative>

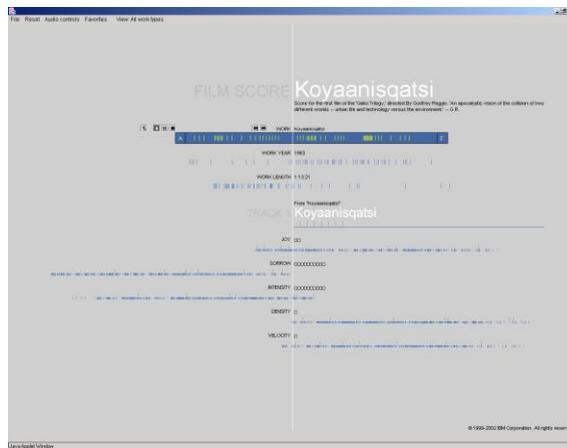
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www.philipglass.com/glassengine

Philip Glass Music



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NY Times



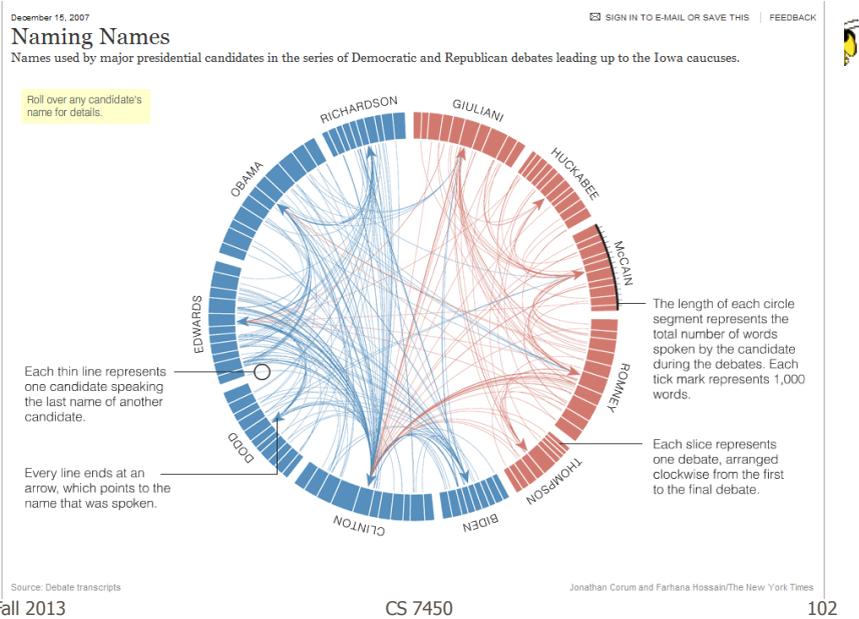
- Has been a wonderful source of interactive data visualizations
- Some examples...

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<http://www.nytimes.com/interactive/2007/12/15/us/politics/DEBATE.html#>



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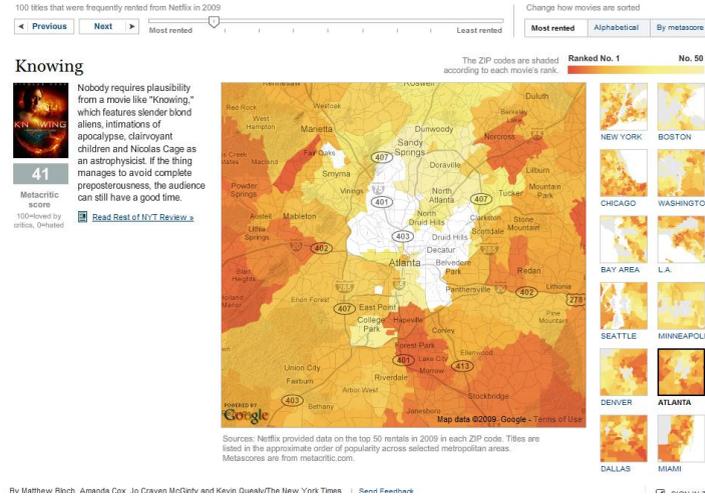
102

http://www.nytimes.com/interactive/2010/01/10/nyregion/20100110-netflix-map.html?hp

Published: January 10, 2010

A Peek Into Netflix Queues

Examine Netflix rental patterns, neighborhood by neighborhood, in a dozen cities. Some titles with distinct patterns are *Mad Men*, *Obsessed* and *Last Chance Harvey*. [Comments \(121\)](#)

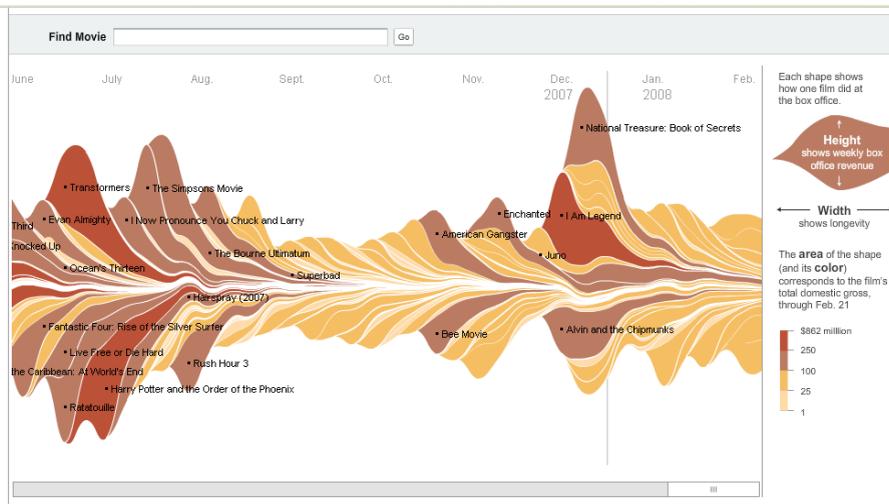


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http://www.nytimes.com/interactive/2008/02/23/movies/20080223_REVENUE_GRAPHIC.html



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Casualties of War

FACES ANALYSIS THEIR STORIES

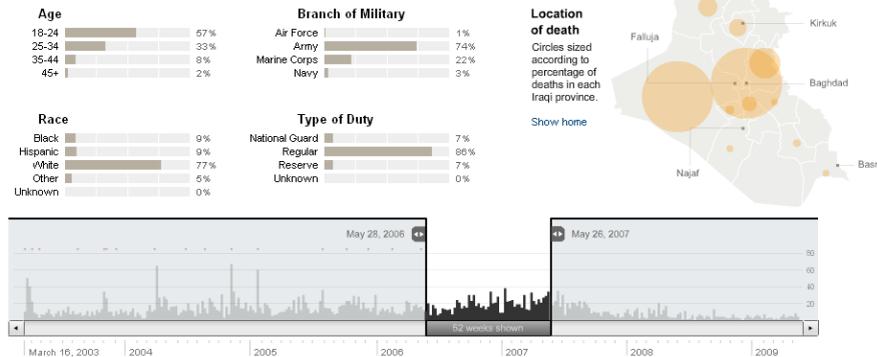
E-MAIL FEEDBACK

Use the slider below to investigate the demographics and military status of U.S. service members who died during the war in Iraq.

MAY 28, 2006 — MAY 26, 2007 (52 WEEKS)

Show all Initial invasion First invasion of Falluja Second invasion of Falluja Since troop buildup began

992 deaths



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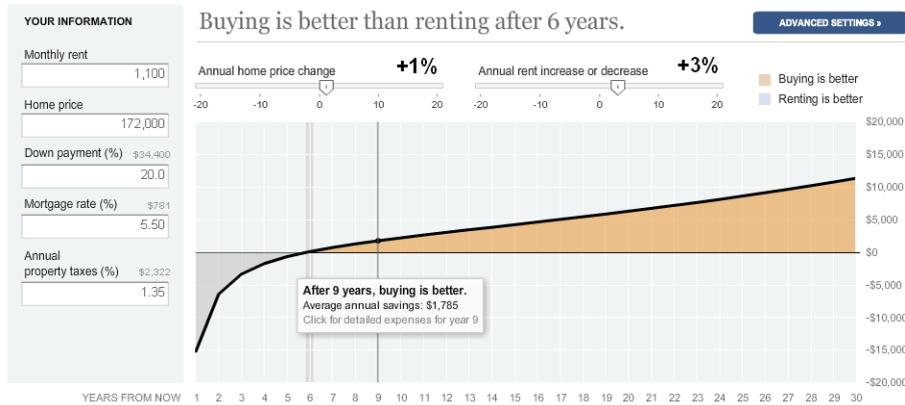
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UPDATED April 21, 2010

Is It Better to Buy or Rent?

Whether renting is better than buying depends on many factors, particularly how fast prices and rents rise and how long you stay in your home. Compare the costs of buying and renting a home in the calculator below. Click the **ADVANCED SETTINGS** button to change inputs such as your rate of return on investments, condo/common fees and your tax bracket.

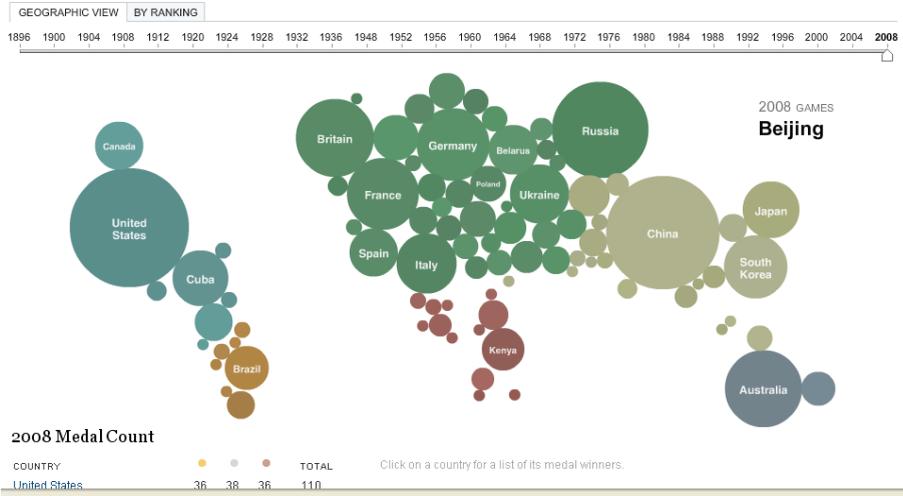


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http://www.nytimes.com/interactive/2008/08/04/sports/olympics/20080804_MEDALCOUNT_MAP.html



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Good Resources



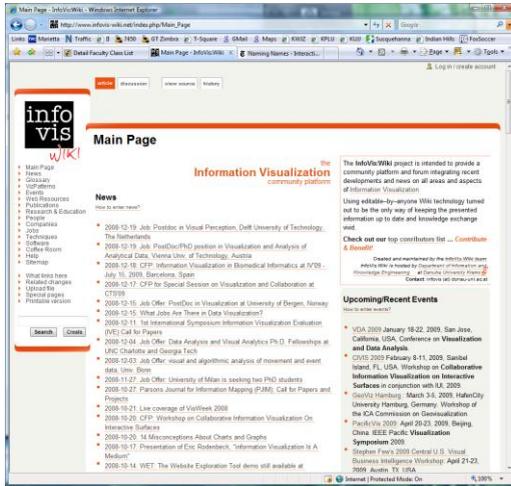
- Some places to look for more information

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InfoVis Wiki

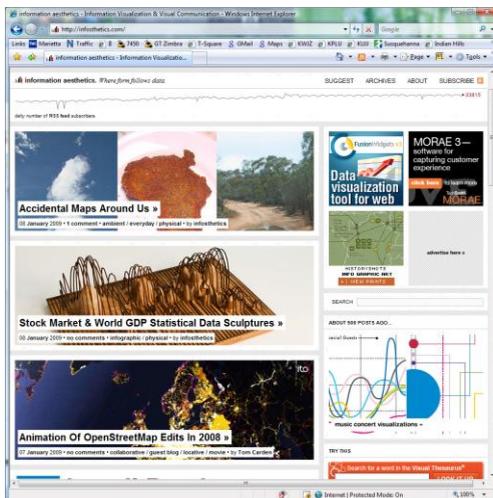


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Infosthetics Blog



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Visualizing.org

<http://www.visualizing.org>



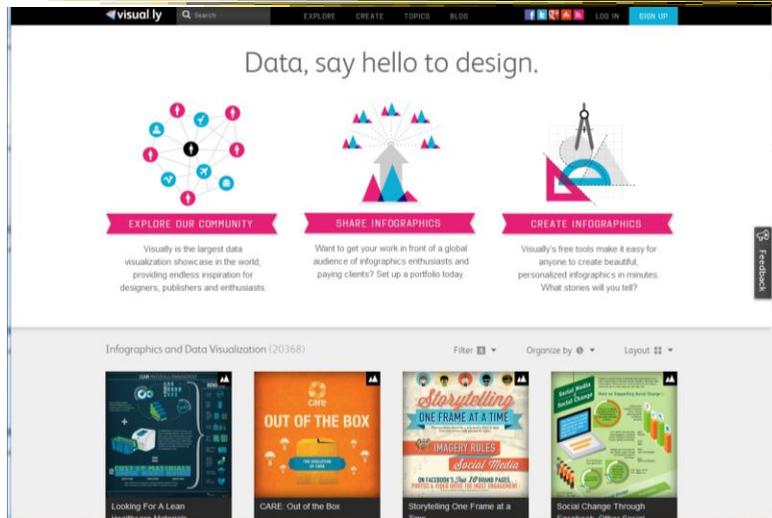
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Visual.ly

<http://visual.ly/>



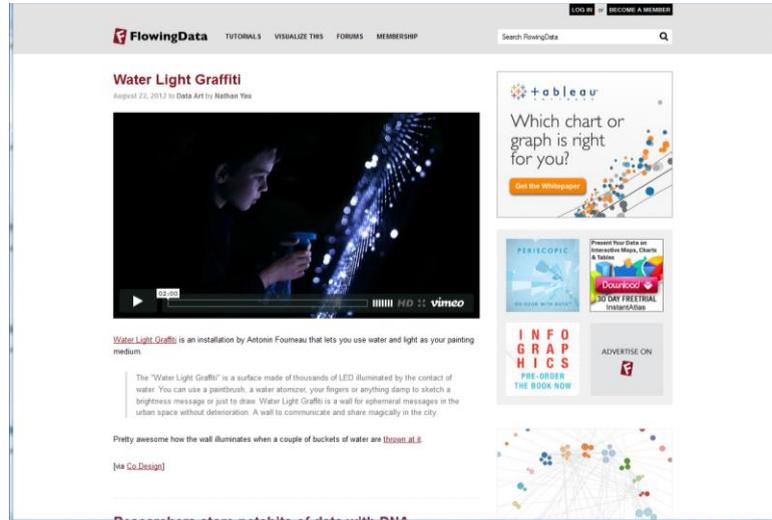
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Flowing Data

http://flowingdata.com/



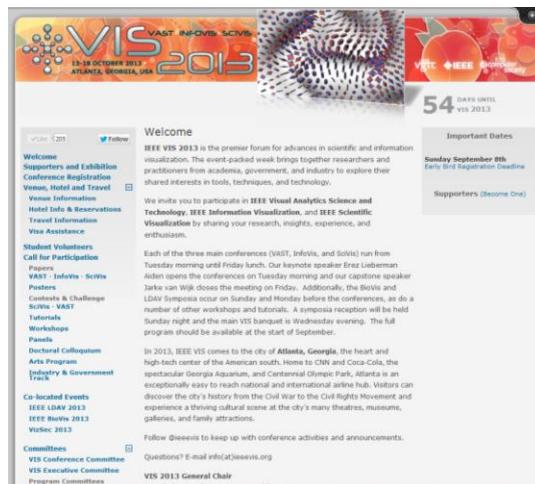
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VIS '13

http://ieevis.org



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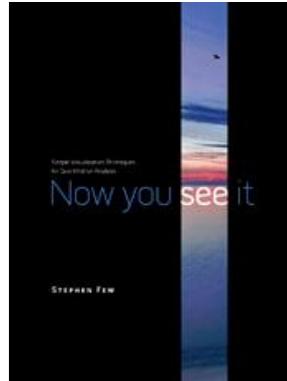
114

Oct. 13-18
Marriott Marquis

S. Few Book



- Chapters 1-3



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Administrative Matters



- Review
- Questions?

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HW



- HW1 due next Monday
 - Data Exploration and Analysis
 - Bring 2 hardcopies

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Upcoming



- Visual Perception
 - Reading:
M. Stone – web article
- Value/Benefits of Visualization
 - Reading:
Fekete et al '08
van Wijk '05

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