

Overview of InfoVis



CS 7450 - Information Visualization
Aug. 24, 2016
John Stasko

Learning Objectives



- Articulate definition and purpose of visualization
- Describe two main uses or applications of visualization
- List two primary components of visualizations
- Describe the different areas of academic visualization research
- Explain the infovis “pipeline” (process)

Exercise



- Get out pencil and paper

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Electronics



- This is now a **NO** laptops/cellphones class
- Exceptions will be noted (exercises, etc)
- Note-takers, see me

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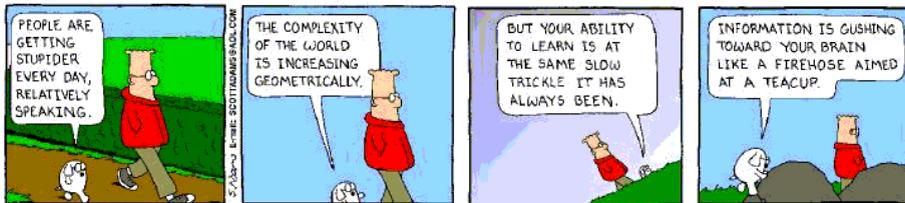
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Data Overload



- 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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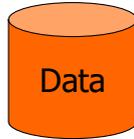
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The Problem



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



Data Transfer →



How?

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

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
- People think visually



Impressive. Lets use it!

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An Example



- Why visualization helps...

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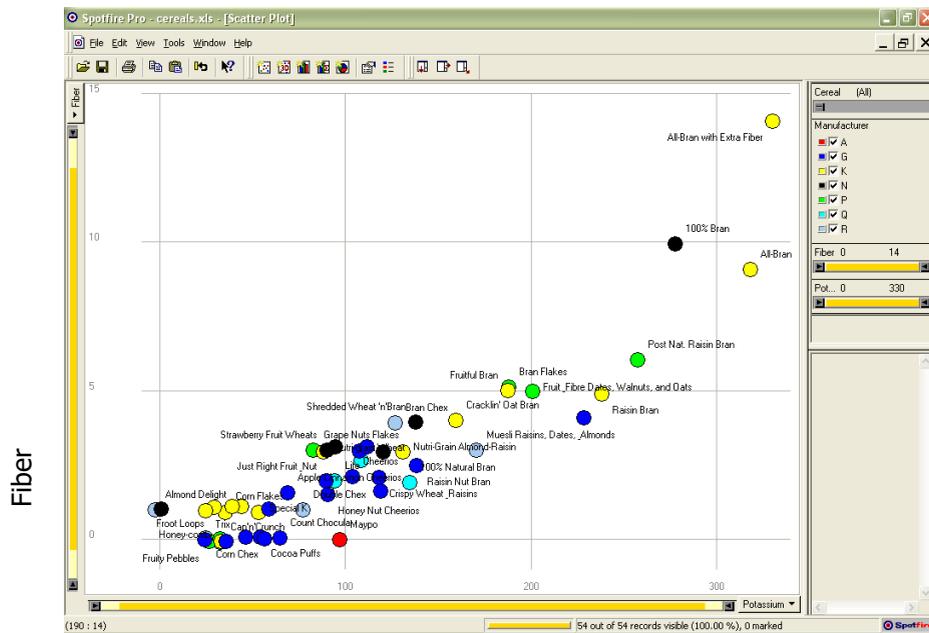
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Questions: Which cereal has the most/least potassium?
 Is there a relationship between potassium and fiber?
 If so, are there any outliers?
 Which manufacturer makes the healthiest cereals?



	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, & Almonds	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, Walnuts & Raisins	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



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Potassium

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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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Another Illustrative Example

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Four Data Sets



- Mean of the x values = 9.0
- Mean of the y values = 7.5
- Equation of the least-squared regression line is: $y = 3 + 0.5x$
- Sums of squared errors (about the mean) = 110.0
- Regression sums of squared errors (variance accounted for by x) = 27.5
- Residual sums of squared errors (about the regression line) = 13.75
- Correlation coefficient = 0.82
- Coefficient of determination = 0.67

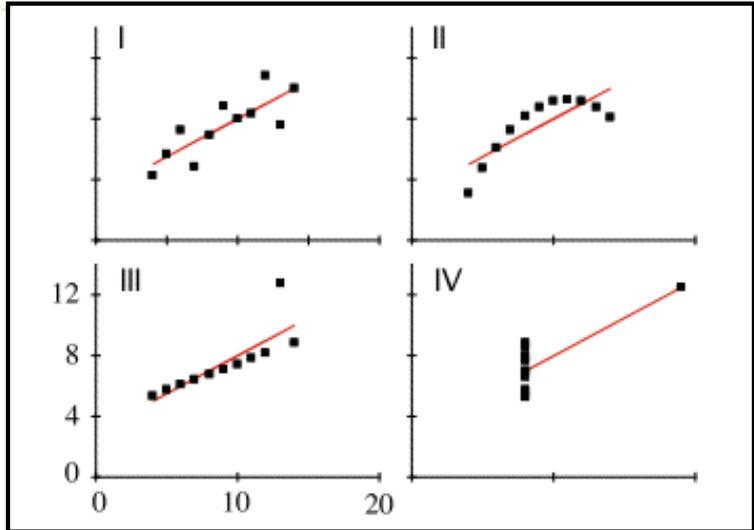
<http://astro.swarthmore.edu/astro121/anscombe.html>

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The Data Sets



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The Values



1	2	3	4
10.0, 8.04	10.0, 9.14	10.0, 7.46	8.0, 6.58
8.0, 6.95	8.0, 8.14	8.0, 6.77	8.0, 5.76
13.0, 7.58	13.0, 8.74	13.0, 12.74	8.0, 7.71
9.0, 8.81	9.0, 8.77	9.0, 7.11	8.0, 8.84
11.0, 8.33	11.0, 9.26	11.0, 7.81	8.0, 8.47
14.0, 9.96	14.0, 8.10	14.0, 8.84	8.0, 7.04
6.0, 7.24	6.0, 6.13	6.0, 6.08	8.0, 5.25
4.0, 4.26	4.0, 3.10	4.0, 5.39	19.0, 12.50
12.0, 10.84	12.0, 9.13	12.0, 8.15	8.0, 5.56
7.0, 4.82	7.0, 7.26	7.0, 6.42	8.0, 7.91
5.0, 5.68	5.0, 4.74	5.0, 5.73	8.0, 6.89

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More on this Topic



- “Value of visualization” lecture later in term

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Exercise Redux



- Let’s check what you did...

- People work differently

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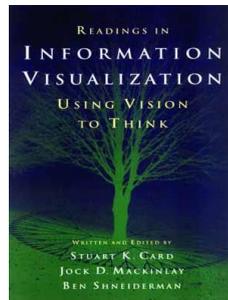
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Visualization



- Definition
 - “The use of computer-supported, interactive visual representations of data to amplify cognition.”

From



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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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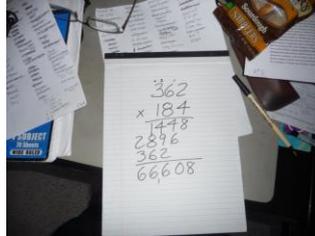
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Visuals Help Us Think



- 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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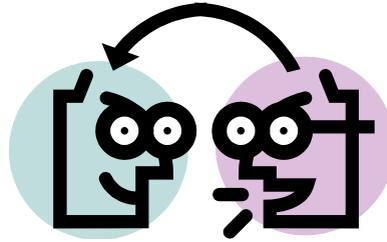
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Part of our Culture



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



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Admin Intermission



- Overloads
- Surveys
- More...

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Administratia



- Get it all from class website
 - Schedule
 - Assignments
 - Instructor & TA
 - Related Courses
 - InfoVis Resources



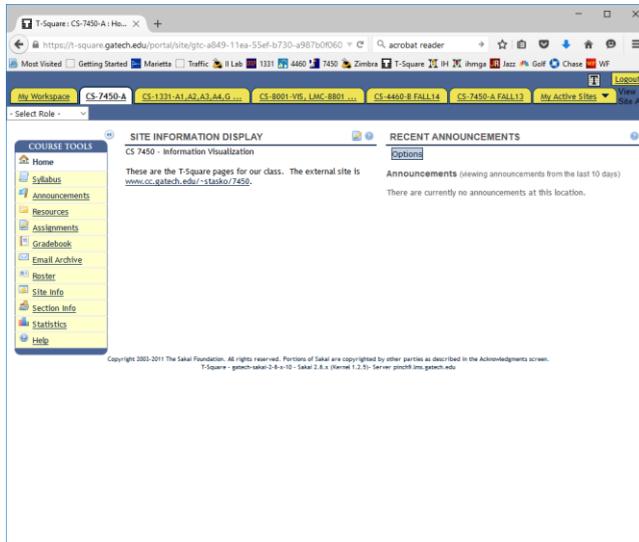
<http://www.cc.gatech.edu/~stasko/7450>

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T-Square Site



Get lecture slides from last time there

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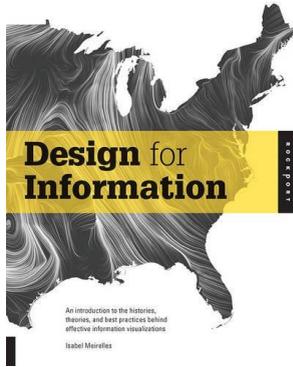
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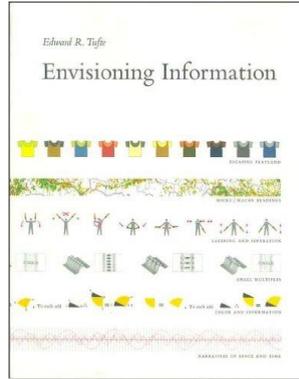
Books



Required



Recommended



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Schedule



Info
central

Schedule

Link to last time's 2015 schedule with lecture slides

Week	Dates	Topic	Topic	HW
1	Aug 22, 24	Introduction	InfoVis overview	HW 1
2	Aug 29, 31	Multivariate data & tables	Graphs and charts	
3	Sep 5, 7	No Class - Labor Day	Visual perception	
4	Sep 12, 14	Multivariate visual representations 1	Multivariate visual representations 2	
5	Sep 19, 21	Vis programming tutorial	InfoVis systems & toolkits	
6	Sep 26, 28	Interaction	Overview & detail	
7	Oct 3, 5	Tasks and analysis	Poster session	
8	Oct 10, 12	No Class - Fall break	Storytelling	
9	Oct 17, 19	Tufte's design processes	Causal infoVis	
10	Oct 24, 26	Wiki card	Value of visualization (Video)	
11	Oct 31, Nov 2	Text & documents 1	Text & documents 2	
12	Nov 7, 9	Hierarchies & trees 1	Hierarchies & trees 2	
13	Nov 14, 16	Graphs and networks 1	Graphs and networks 2	
14	Nov 21, 23	Time series data	No Class - Thanksgiving break	
15	Nov 28, 30	Visual analytics	Exam	
16	Dec 5, 9	Evaluation	Project presentations	

Detail

Below are summaries of all the materials for each class. Lecture slides, references for readings and articles, videos shown, and software demonstrated are listed for each topic. Also available is a more general, alphabetical bibliography.

R - Post class readings

Aug. 22 - Introduction

Readings

- Tufte Shuttle recap R

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Flipped Readings



- No reading assignment previewing next class' material
- Instead, reading of papers and viewing of videos/websites from current class for next time
 - Potential pop quiz at start of next class

Look for **R** on Schedule webpage

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Grading



- Participation
- Pop Quizzes
- Assignments
 - HWs (about 7)
- Project
- Final Exam

- (Details still being finalized)

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Survey



- Who wasn't here on Monday and didn't fill out a survey?
- If you want to change your "I'm on WL and not sure I want in" to "I'm on WL and I definitely want in" see me after class

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*** **CAVEAT** ***



- This course is a lot of work. If you're just looking for some easy grade, I would advise you to drop now.
- If you are sincerely interested in this topic, I hope you will enjoy the course and learn a lot

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Waitlist/Overload Update



- Status
 - Room capacity
 - Let in 15 yesterday
 - 29 of original 60 said “might drop”
 - Will let in more tomorrow
 - **Please** drop by Thursday noon
 - On Friday it becomes the “Wild West”

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- This is now a **NO** laptops/cellphones class
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- Note-takers, see me

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[Back to content](#)

Purpose



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

1. Analysis



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



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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?

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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?

More on EDA



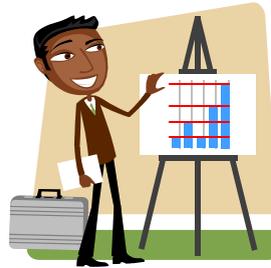
“Information visualization is ideal for exploratory data analysis. Our eyes are naturally drawn to trends, patterns, and exceptions that would be difficult or impossible to find using more traditional approaches, such as tables or text, including pivot tables. When exploring data, even the best statisticians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

S. Few
Now you see it

2. Communication



- Use visualization to communicate ideas, present, 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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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



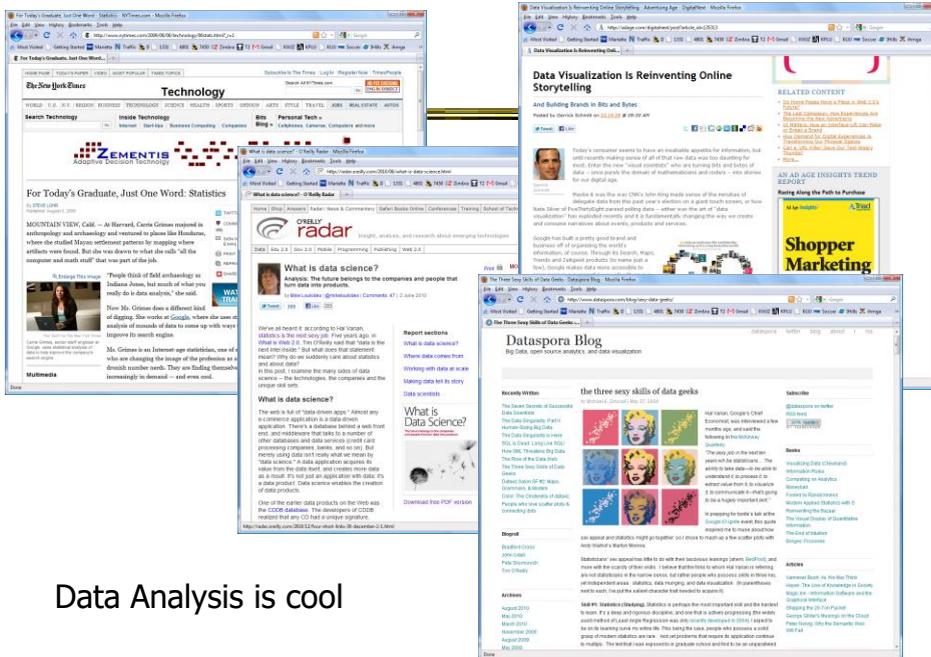
- How to measure and prove?
 - All those benefits are not easily quantifiable and measured
- Evaluation is perhaps primary open research challenge for visualization

More to come later in term

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Data Analysis is cool

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Academic Areas



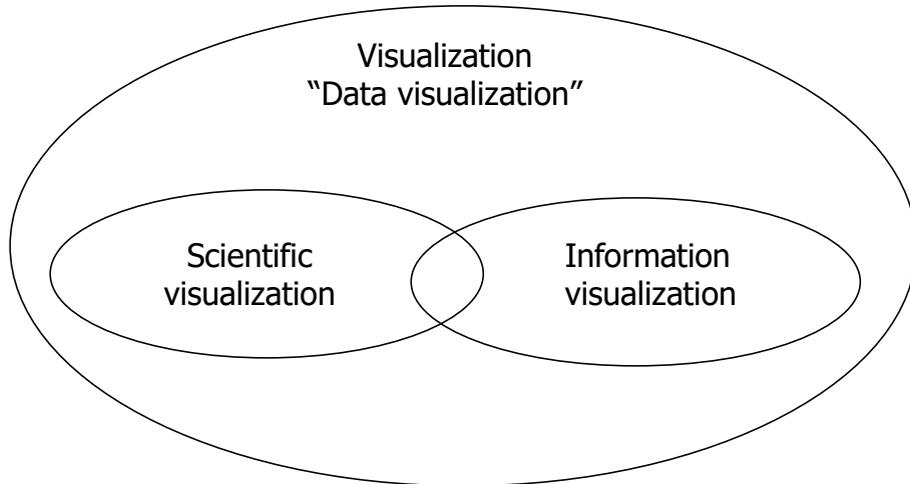
- Where does InfoVis fit in the academic world?

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Overview



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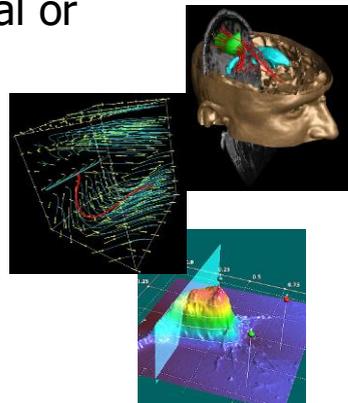
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Scientific Visualization



- Primarily relates to and represents something spatial, 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”?
 - Non-spatial data: 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...

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Information Visualization



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

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Information Visualization



- Characteristics:
 - Taking things without a direct physical correspondence (non-spatial) 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



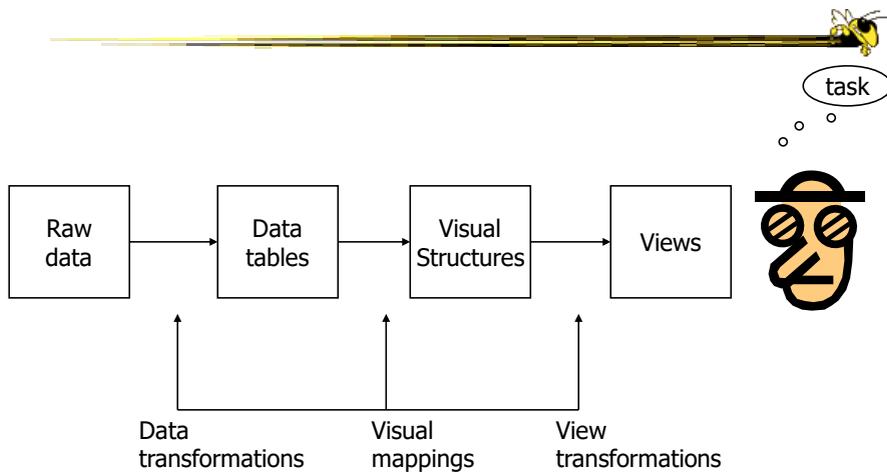
- Text
- Statistics
- Financial/business data
- Internet information
- Software
- ...

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InfoVis Process Model



From: Card, Mackinlay, Shneiderman '99

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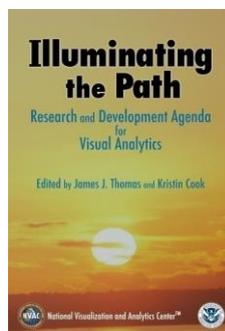
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New Area Emerging: Visual Analytics

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

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



More to come
later in term

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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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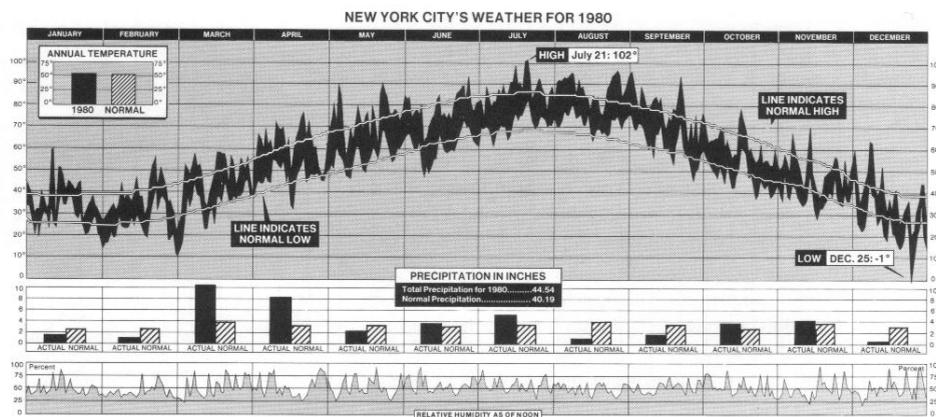
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NYC Weather



2220 numbers



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

Tufte, Vol. 1

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Data Values



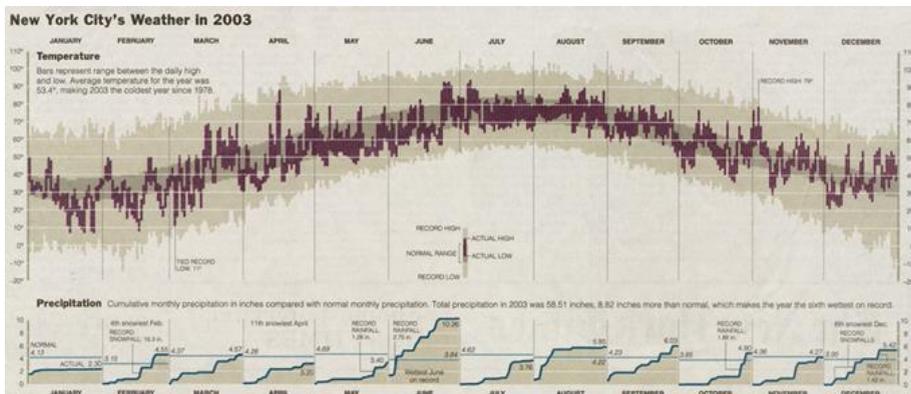
- 365 High temp for each day
- 365 Low temp for each day
- 365 Avg high temp for each day
- 365 Avg low temp for each day
- 365 Precipitation for each day
- 365 Humidity for each day
- 12 Precipitation for each month
- 12 Avg precipitation for each month
- 1 Precipitation for the year
- 1 Avg precipitation per year
- 1 Highest temp (& day) for the year
- 1 Lowest temp (& day) for the year
- 1 Avg daily temp for the year
- 1 Avg daily temp per year

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Updated Version

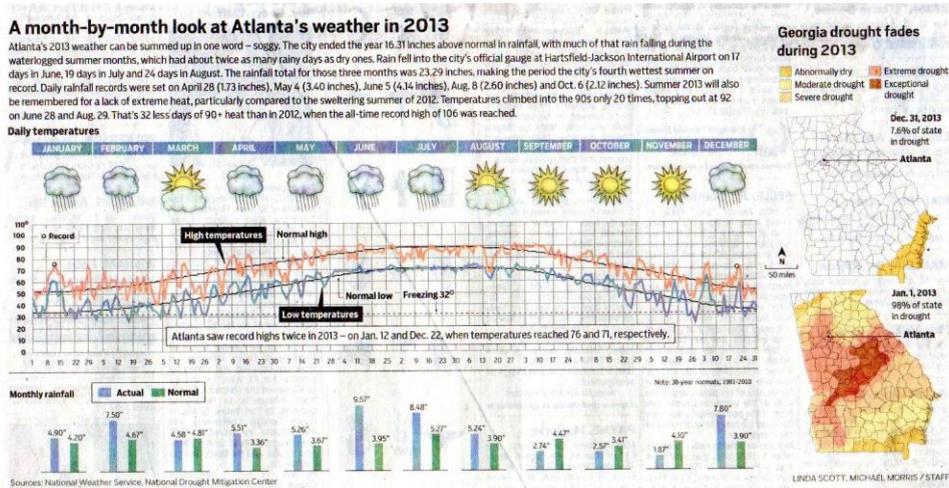


http://www.edwardtufte.com/bboard/q-and-a-fetch-msg?msg_id=00014g

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Atlanta Journal Constitution Jan. 3, 2014

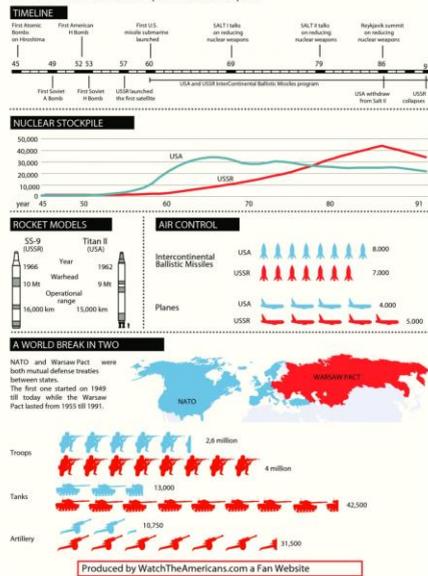
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THE NUCLEAR ARMS RACE

It was the main issue in the Cold War when both America and Russia challenging each other to increase their stockpiles of nuclear weapons.



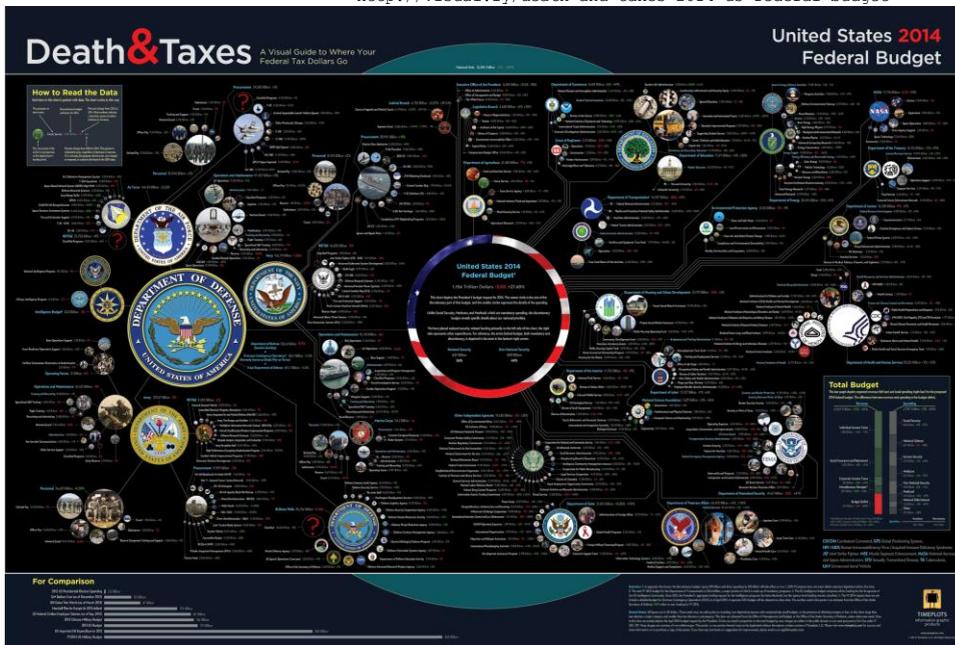
<http://visual.ly/nuclear-arms-race>

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<http://visual.ly/death-and-taxes-2014-us-federal-budget>



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<http://www.mikewirthart.com/?cat=3>

Beer

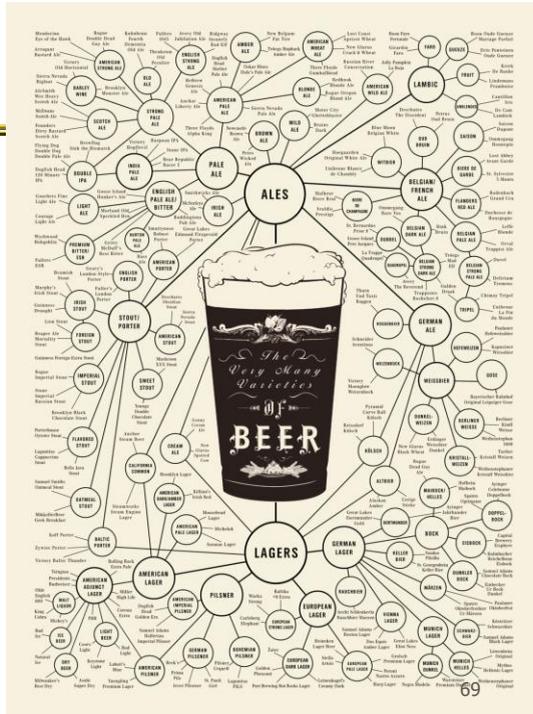


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Beer!



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

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More Beer!

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The Beerionic Table

01 Berliner Weisse	02 Belgian Wit	03 American Wheat	04 Weizen	05 Dunkelweizen	06 Weizenbock	07 Lambic/Gueuze	08 Faro	09 Fruit beer	10 Flanders Red	11 Oud Bruin	12 Belgian Pale	13 Saison	14 Biere de Garde	15 Flanders Strong Pale	16 Belgian strong dark	17 Tripel	18 Dubbel	19 ABT	20 Quadruple	21 Pale Ale	22 India Pale Ale	23 A. Red & Amber Ale	24 Oud Bruin	25 English Pale	26 Bitters	27 Imperial IPA	28 A. Red & Amber Ale	29 Scotch Ale	30 American Brown	31 English Brown	32 American Brown	33 Foreign Stout	34 Robust Porter	35 Dry Stout	36 California Common	37 Imperial Stout	38 Cream Ale	39 Kölsch	40 American Light	41 Basic Porter	42 Helles Lager	43 American Lager	44 American Dark	45 Helles Lager	46 Helles Lager	47 Bohemian Pilsener	48 American Lager	49 Vienna, Marzen, Oktoberfest	50 Helles Lager	51 Boock	52 Doppel Boock	53 Eibock
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— ALE — — HYBRID — — LAGER —

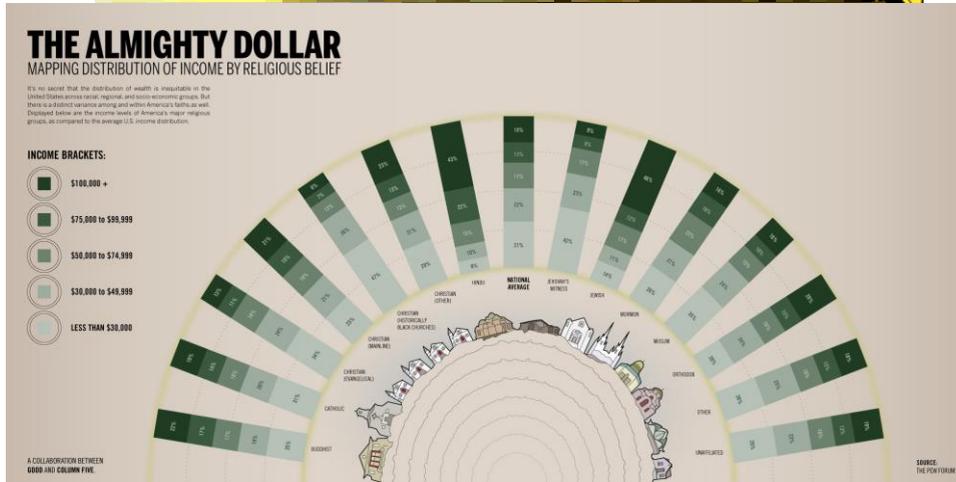
<http://thebeermongers.com/beers/>

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Income and Religion

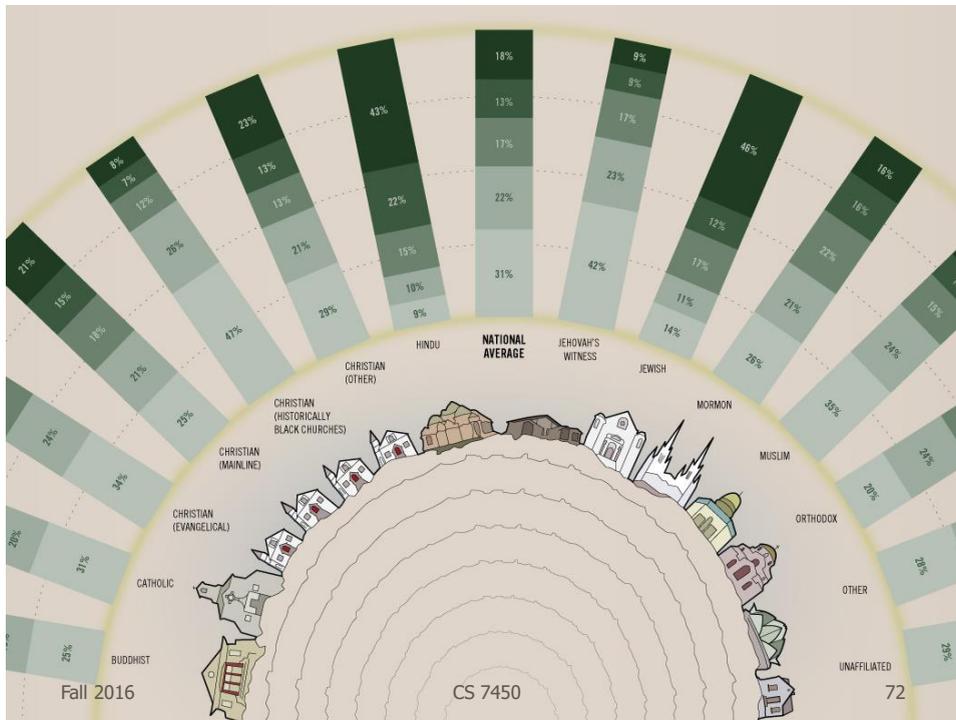


<http://awesome.good.is/transparency/web/1002/almighty-dollar/transparency.jpg>

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Population

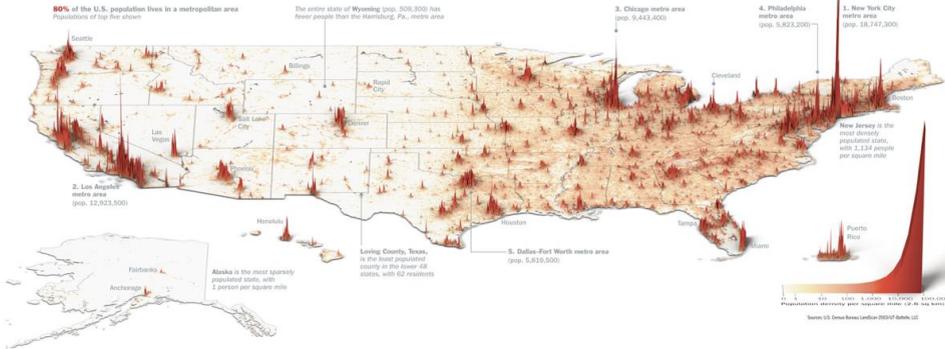


Where We Live...

Unlike many developed countries, the U.S. keeps growing. We are also moving south and west. But compared with China or India, the nation is a vast prairie

Our families are getting smaller—with one vital exception. Compared with those of Europe and Japan, the U.S. population is younger and more colorful because of the continued arrival of immigrants and their higher-than-average birthrates. Of the 300 million Americans who will join us in the next 27 years, half will be immigrants or their children. In the next few decades, 97% of the world's population growth will occur in the developing world; the U.S. is the largest developed country in the world that is still growing at a healthy clip. That matters, strategically, economicall-

Ala.: Primm, Tenn. Ky.; or Louisville, N.Y. But they are all probably close to someone's idea of paradise. —By Nancy Jans



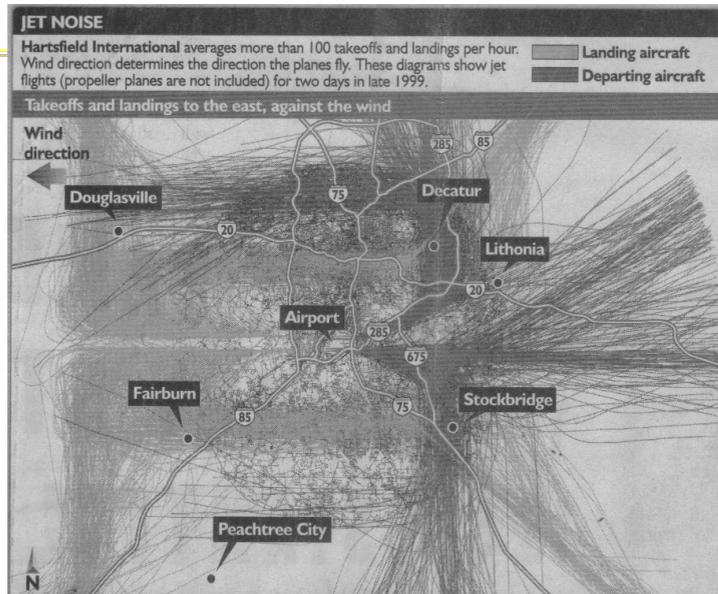
<http://infographicsnews.blogspot.com/2009/04/mantras-joe-lertolas-maps.html>

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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.

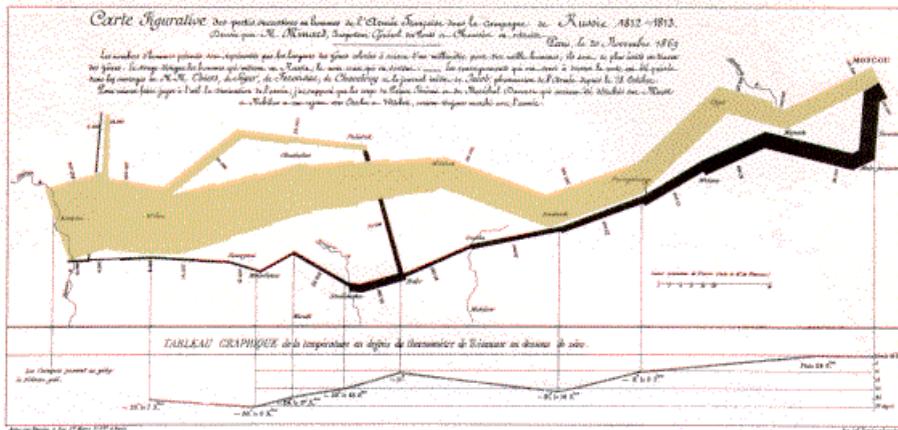
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Napoleon's March

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...

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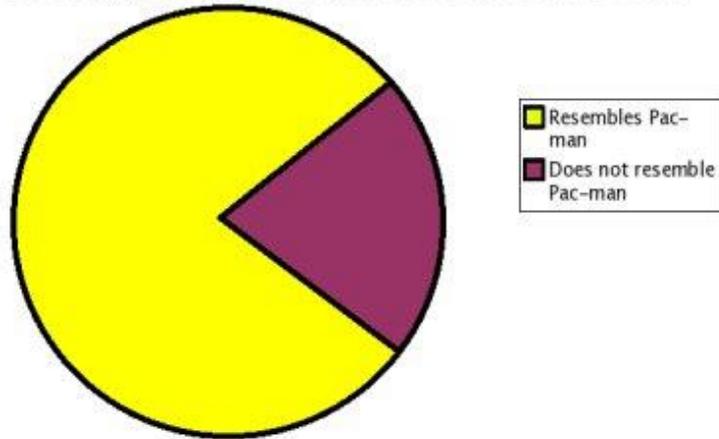
http://infosthetics.com/archives/2008/09/funniest_pie_chart_ever.html

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Percentage of Chart Which Resembles Pac-man

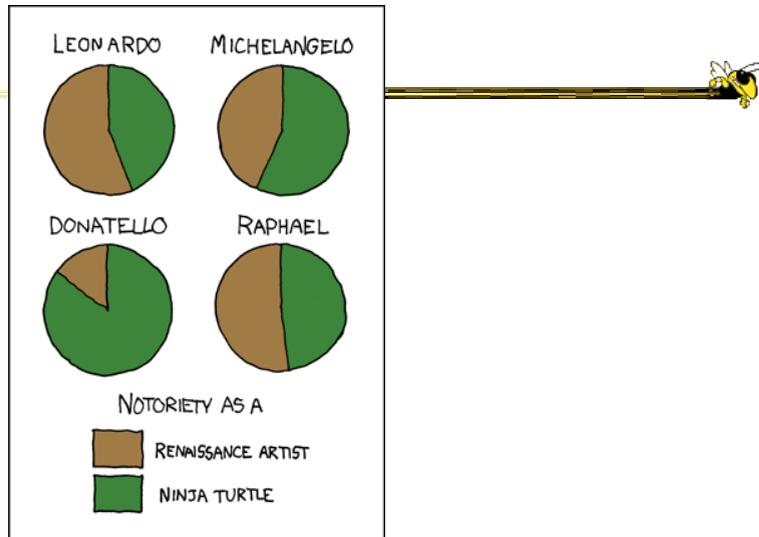


<http://www.boingboing.net/2006/11/02/hilarious-piechartvi.html>

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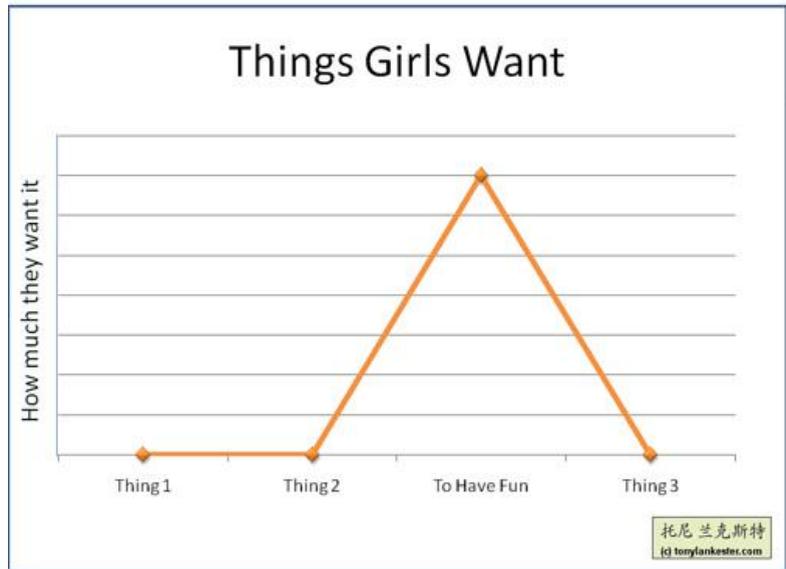


<http://xkcd.com/197/>

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





But Don't Do This

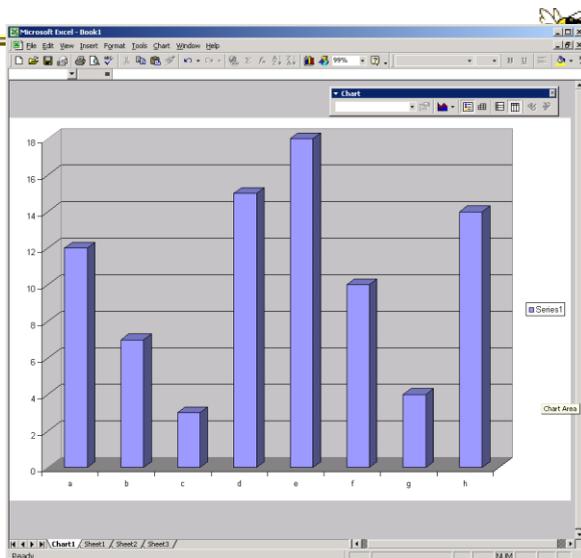
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Excel

Get rid of those darn 3D bars!



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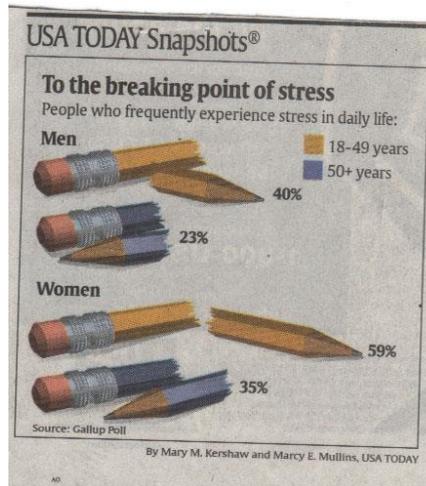
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USA Today Graphics



Or worse yet...



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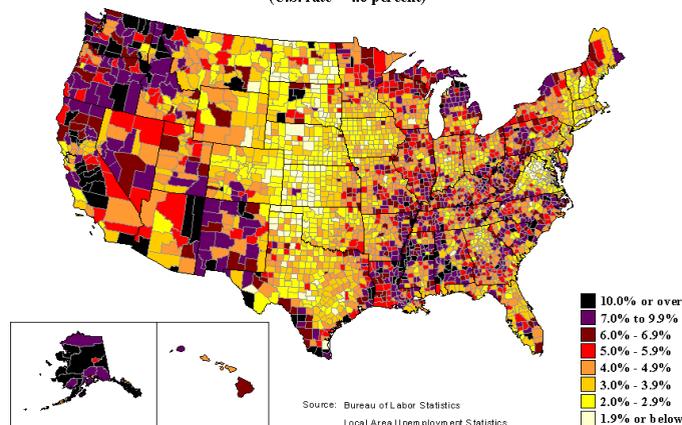
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Unemployment Rates



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

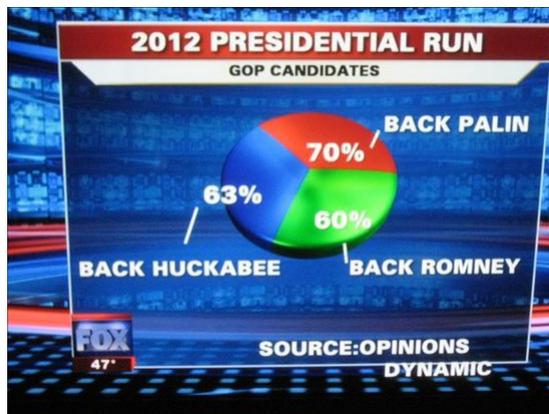


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FOX "News"



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

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Examples



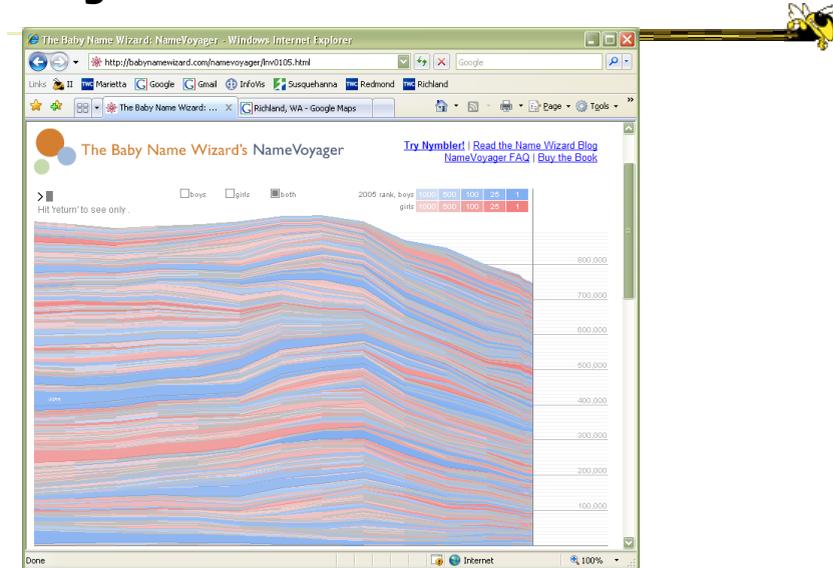
- Tools/Systems
 - Now interaction becomes important...

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Baby Name Wizard



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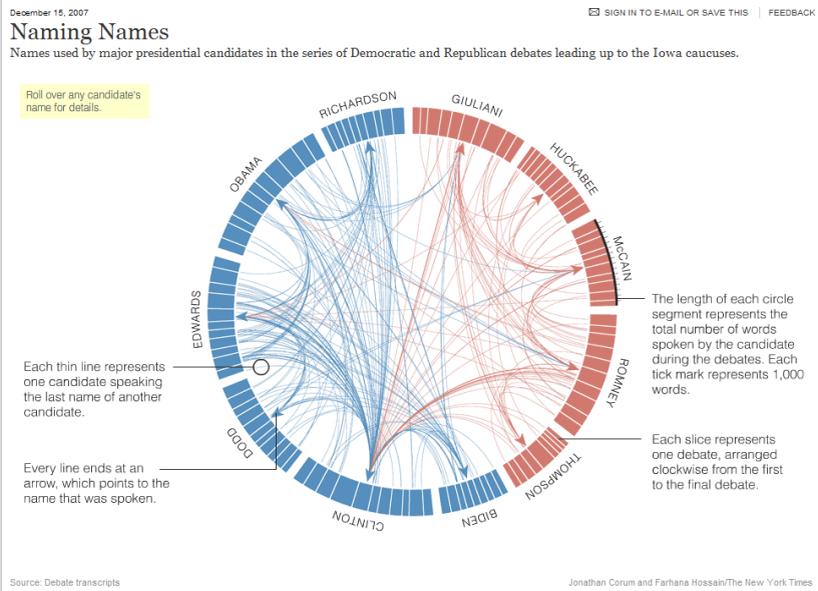
NY Times

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

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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 \(121\)](#)

100 titles that were frequently rented from Netflix in 2009

Change how movies are sorted: **Most rented** | Alphabetical | By metascore

Most rented | Least rented

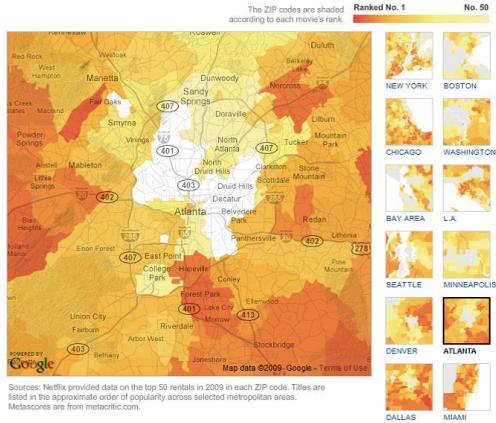
Knowing

Nobody requires plausibility from a movie like "Knowing," which features slender blond aliens, intimations of apocalypse, clairvoyant children and Nicolas Cage as an astrophysicist. If the thing manages to avoid complete preposterousness, the audience can still have a good time.

Metascore: 41

100+ loved by critics, D+ rated

[Read Rest of NYT Review](#)



By Matthew Bloch, Amanda Cox, Jo Craven McGinty and Kevin Queally/The New York Times | Send Feedback

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Good Resources



- Some places to look for more information

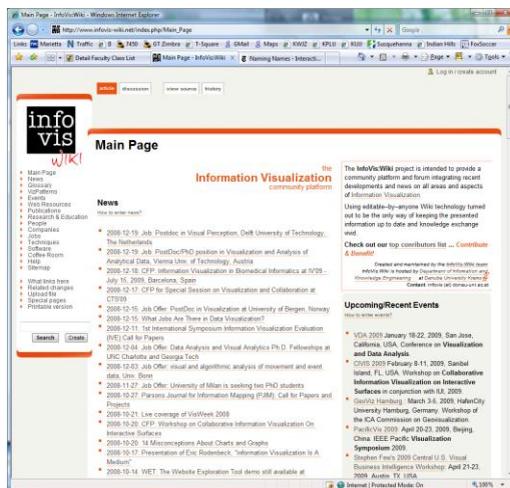
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<http://www.infovis-wiki.net>

InfoVis Wiki



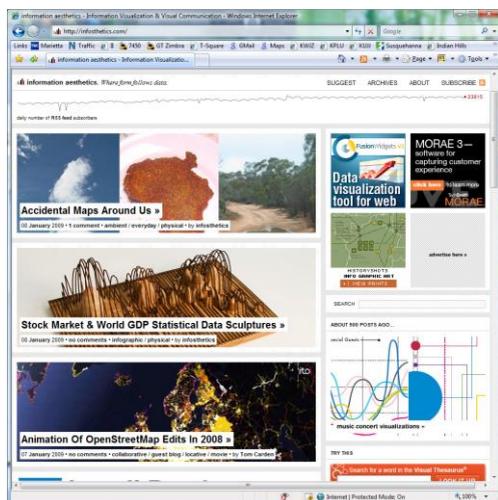
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Infosthetics Blog

<http://infosthetics.com/>



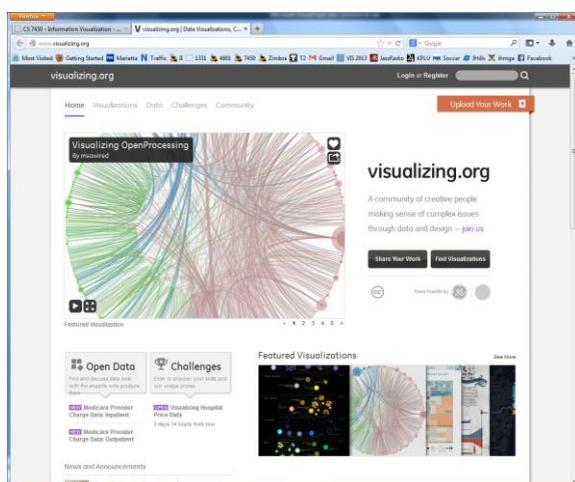
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Visualizing.org

<http://www.visualizing.org>



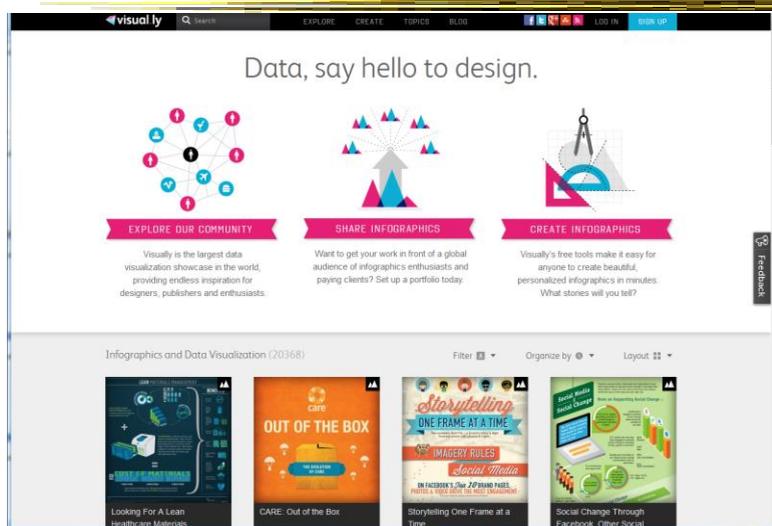
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Visual.ly

<http://visual.ly/>



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Flowing Data

<http://flowingdata.com/>

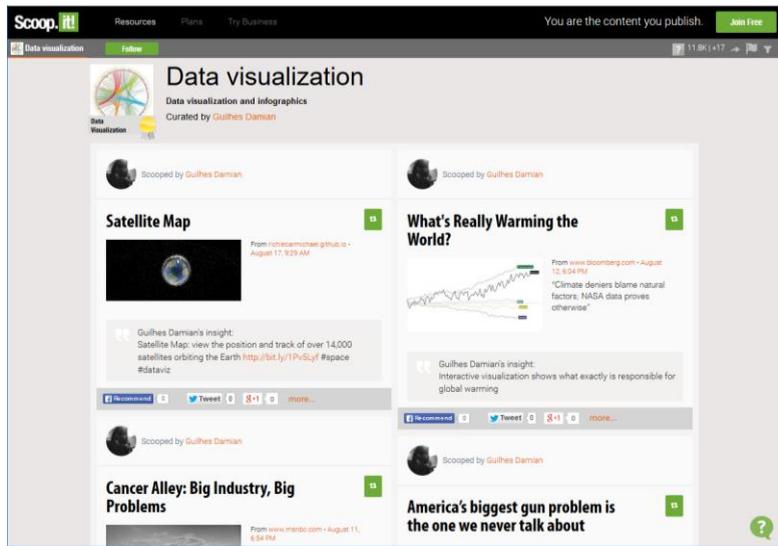


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Scoop.It!

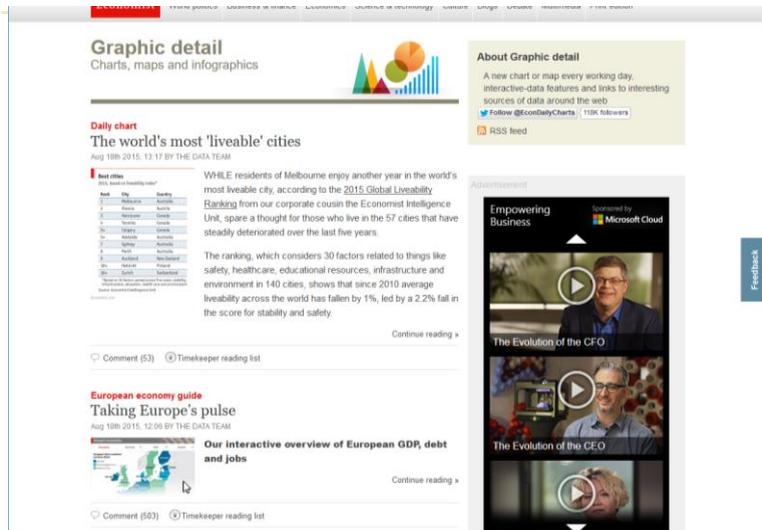


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Graphic Detail - Economist

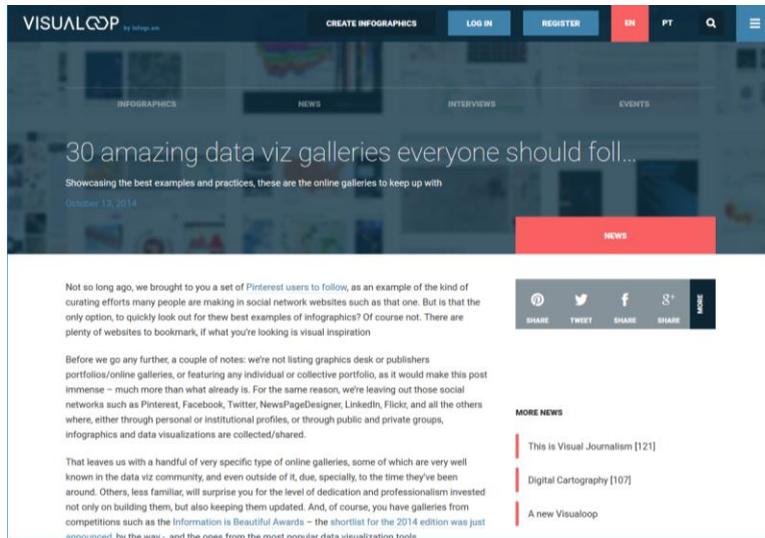


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A Compendium



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Learning Objectives

- Articulate definition and purpose of visualization
- Describe two main uses or applications of visualization
- List two primary components of visualizations
- Describe the different areas of academic visualization research
- Explain the infovis "pipeline" (process)

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HW



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

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Reading



- Card, Mackinlay, Shneiderman
Chapter 1 of their book
- Check out some of the websites on the
Schedule page

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Upcoming



- Multivariate data & tables
- Graphs & Charts