

Viz@UBC: March 5, 2019

A Primer on Data Visualization: Big Insights from Big Data & Small Data

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Founding Director (1983-2000), Human-Computer Interaction Lab
Professor, Department of Computer Science
Member, National Academy of Engineering



Interdisciplinary research community

- Computer Science & Info Studies
- Psych, Socio, Educ, Jour & MITH

www.cs.umd.edu/hcil

vimeo.com/72440805



Designing the User Interface

Design Theories & Research Methods

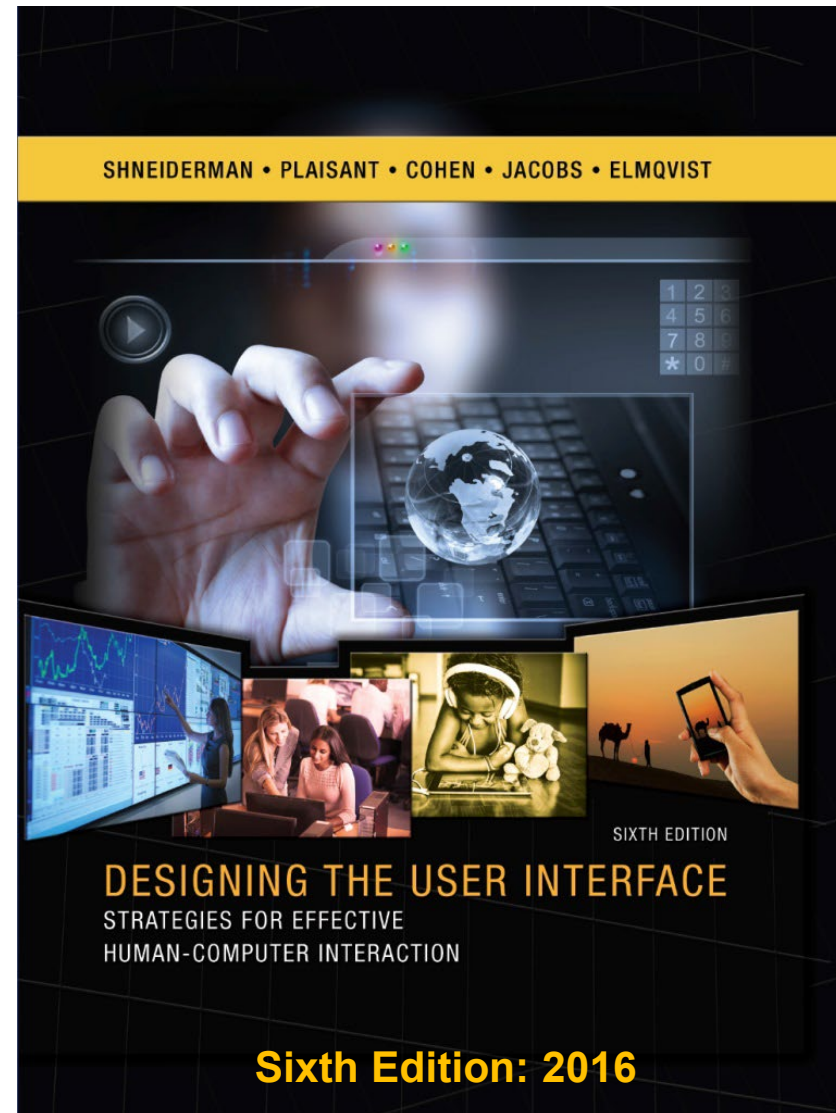
Direct manipulation

Menus, speech, search

Social Media

Information Visualization

www.cs.umd.edu/hcil/DTUI6



Contributions

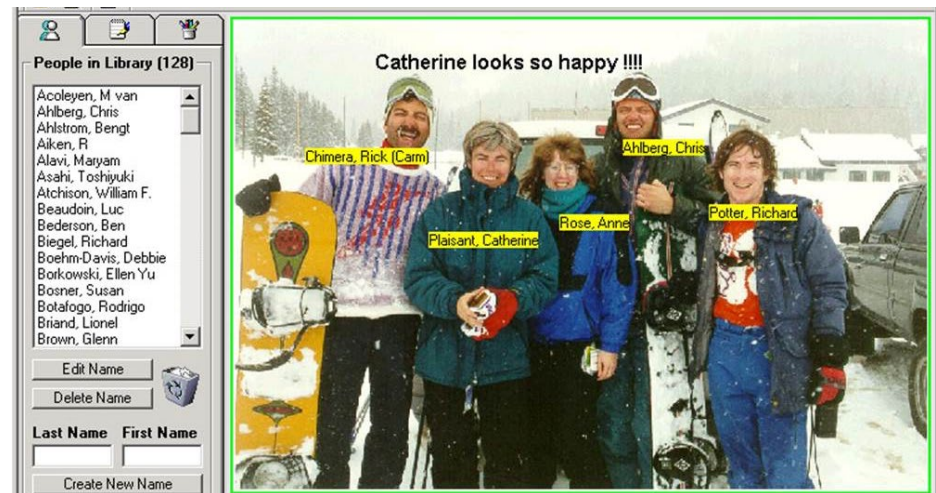
Web links

The **University of Maryland, College Park** (often referred to as the **University of Maryland, Maryland, UM, UMD, UMCP**, or **College Park**) is a public research university^[10] located in the city of **College Park** in **Prince George's County, Maryland**, approximately 4 miles (6.4 km) from the northeast border of Washington, D.C. Founded in 1856, the university is the **flagship** institution of the **University System of Maryland**. With a fall 2010 enrollment of more than 37,000 students, over 100 undergraduate majors, and 120 graduate programs,

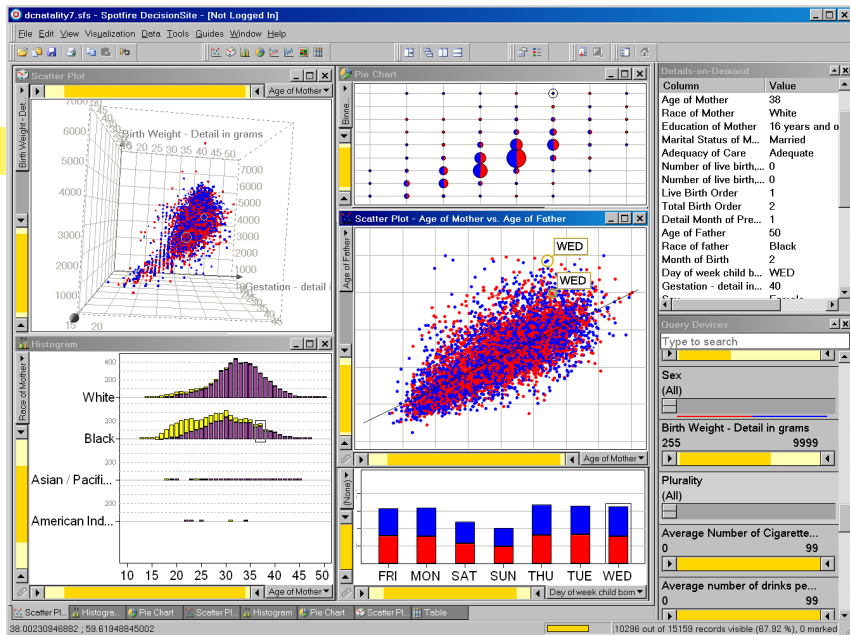
Tiny touchscreen keyboards



Photo tagging



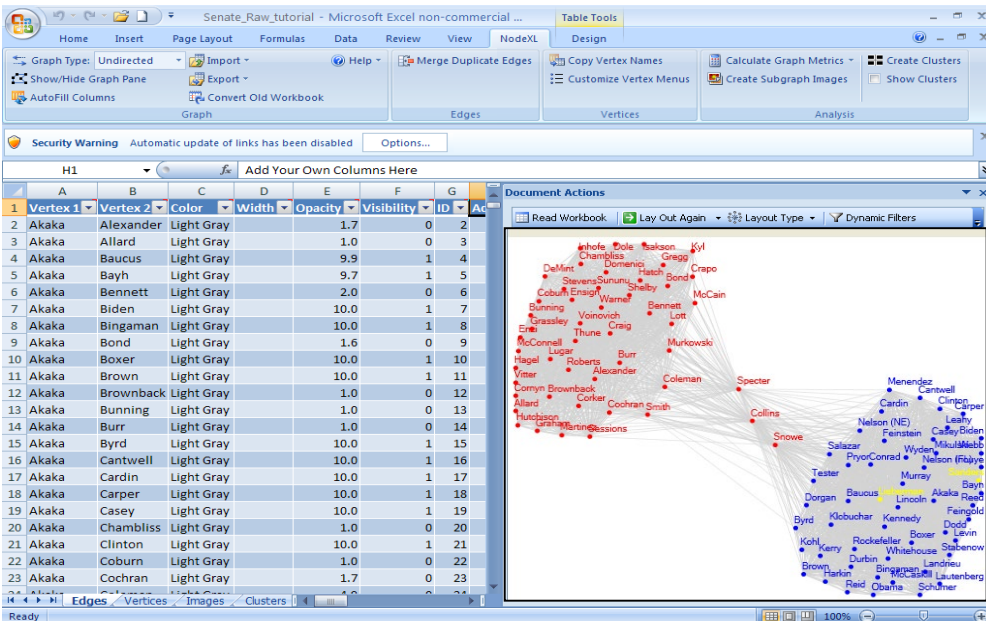
Spotfire



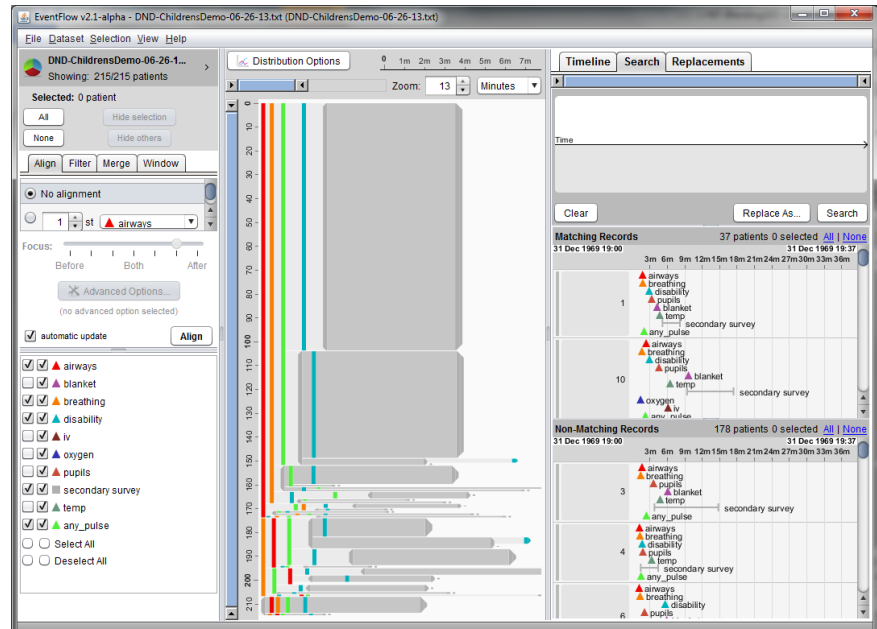
Treemaps FinViz



NodeXL



EventFlow



Information Visualization



- Detect faulty & missing data, unusual distributions, anomalies, outliers

Information Visualization



- Detect faulty & missing data, unusual distributions, anomalies, outliers
- Produce more thorough data analyses & profounder insights

Information Visualization



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- Produce more thorough data analyses & profounder insights
- Develop richer understandings to ask bolder questions

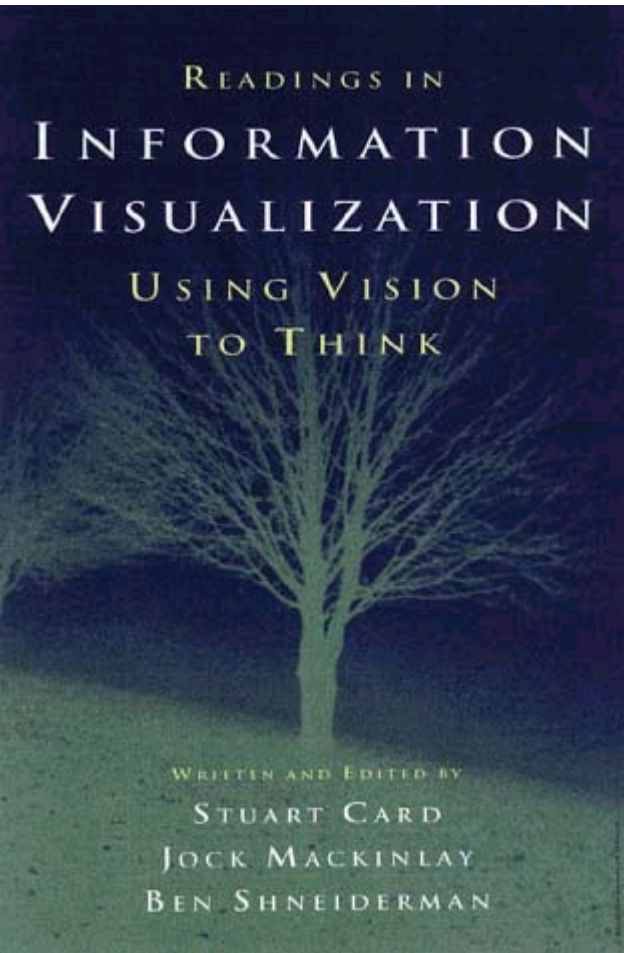
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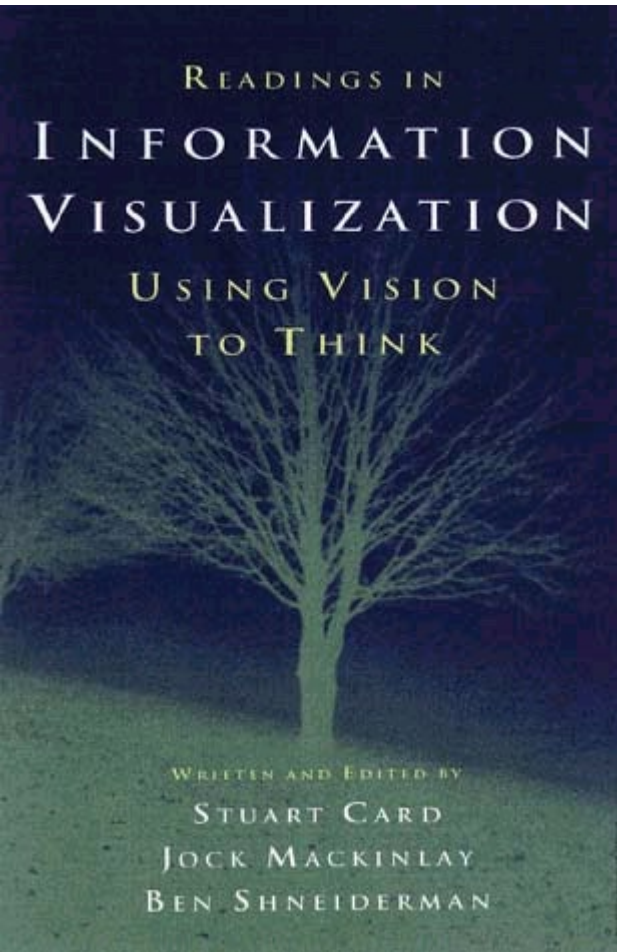
**The purpose of visualization is insight,
not pictures**

Information Visualization & Visual Analytics

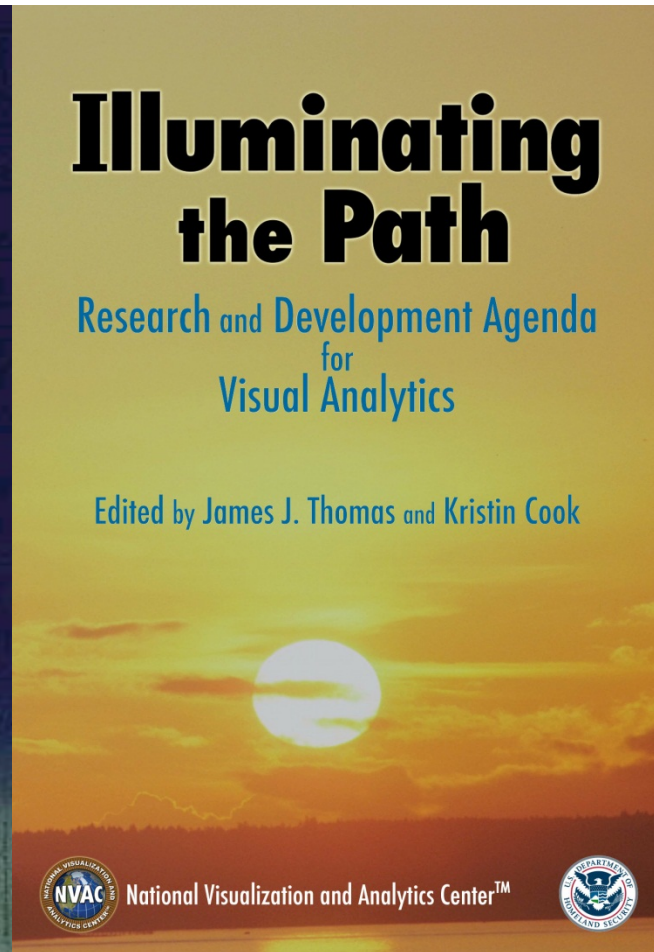


1999

Information Visualization & Visual Analytics



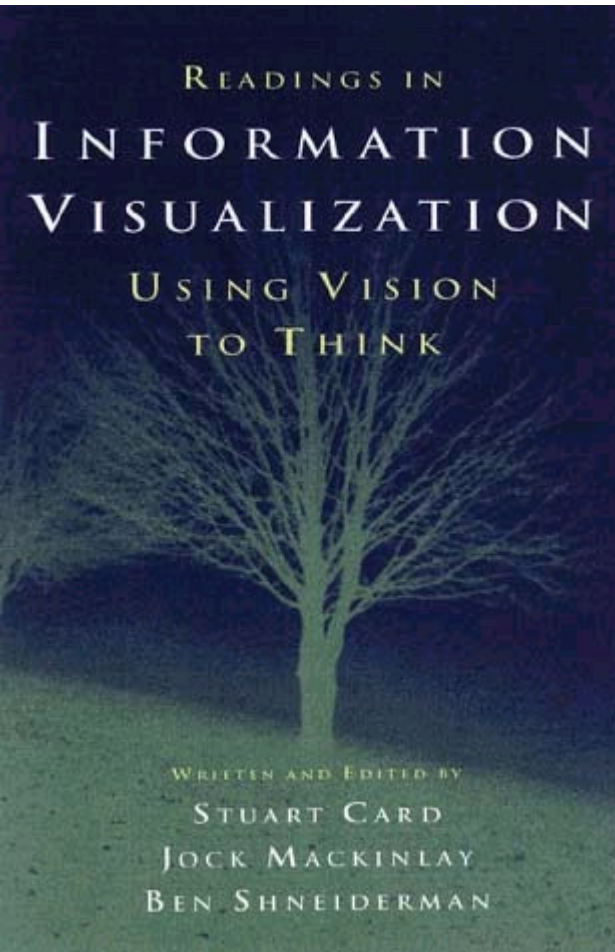
1999



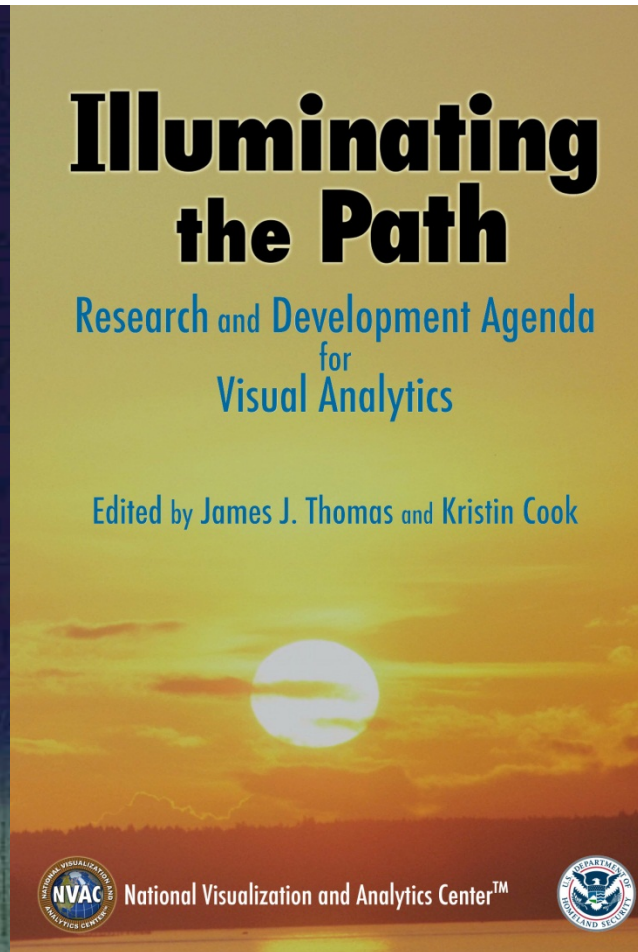
2004



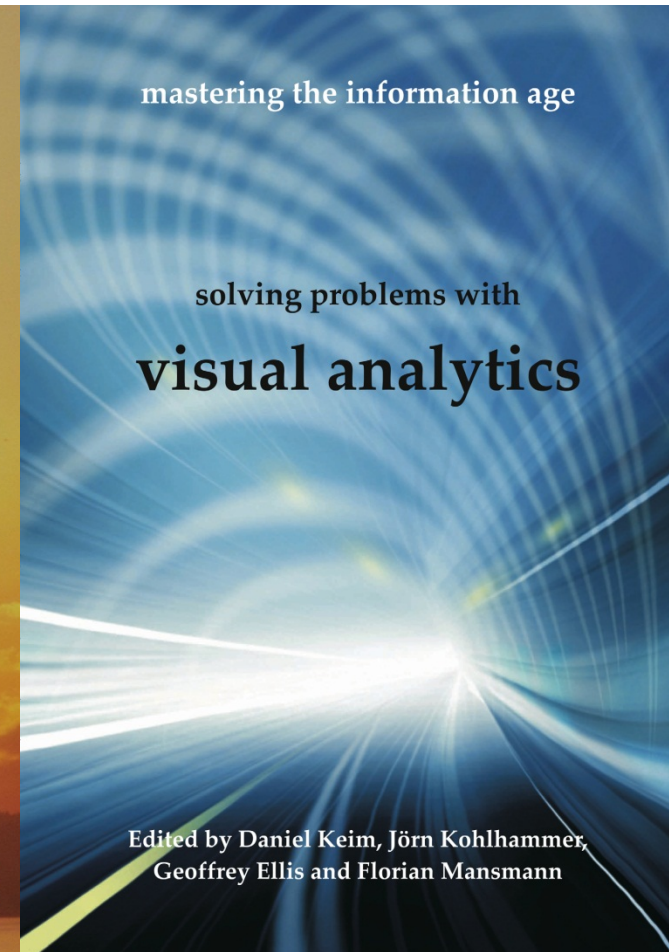
Information Visualization & Visual Analytics



1999



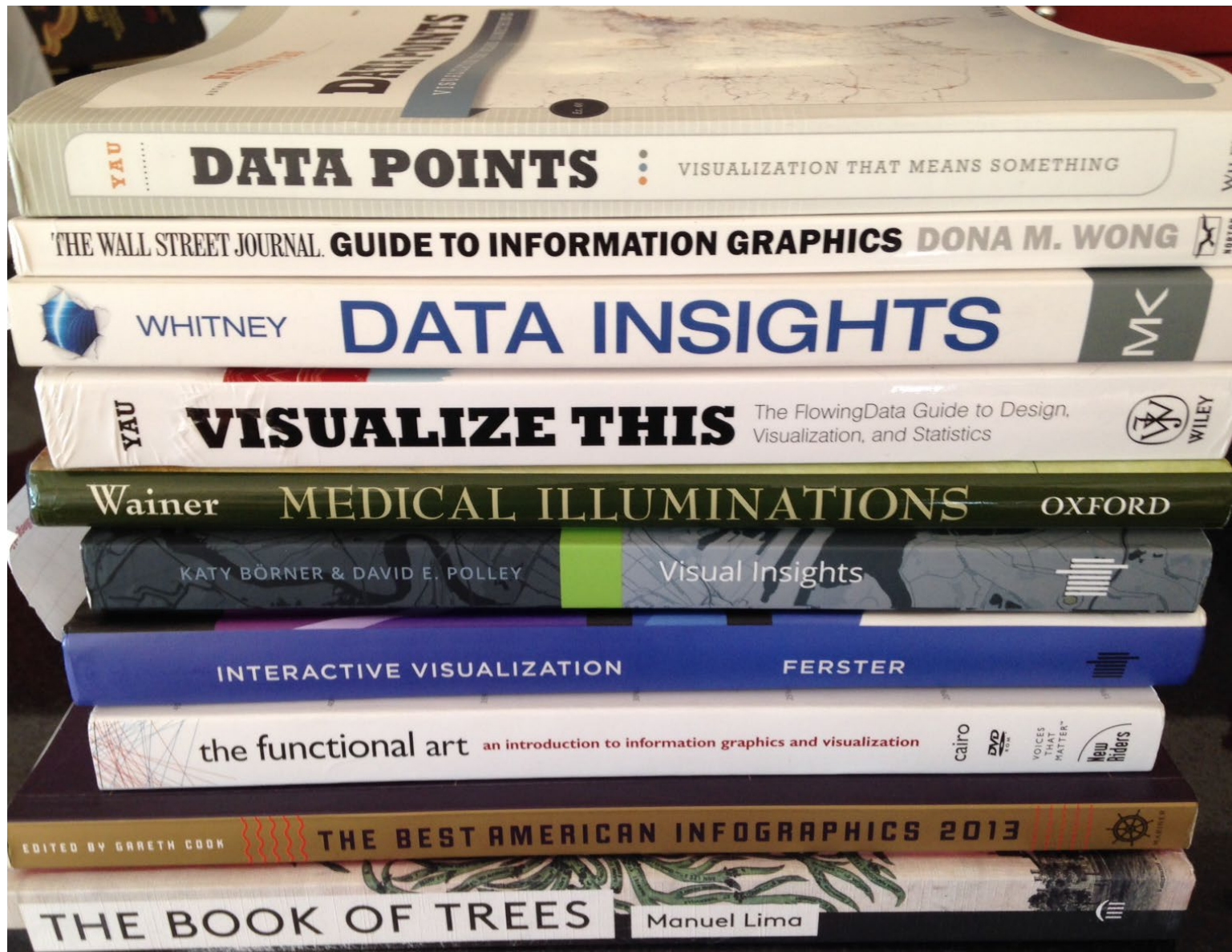
2004



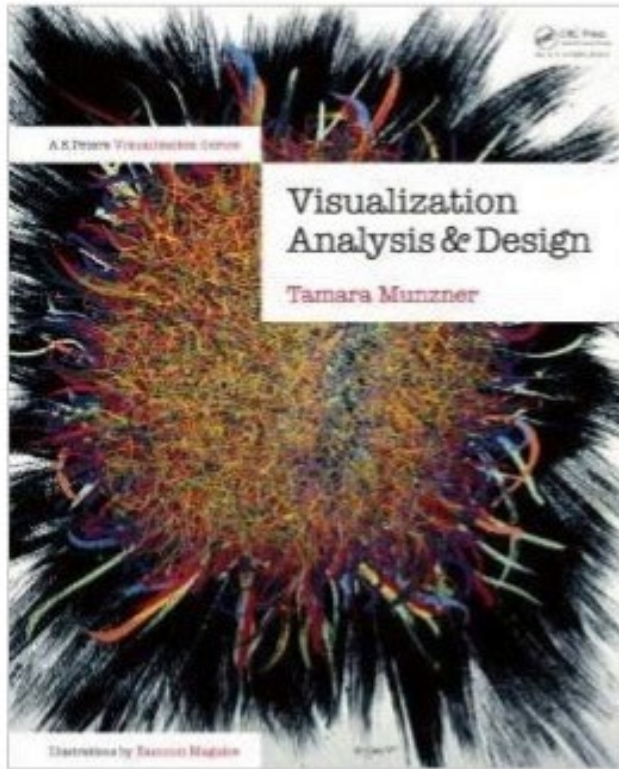
2010



Information Visualization: Cultural Meme



Information Visualization: Textbook



Tamara Munzner

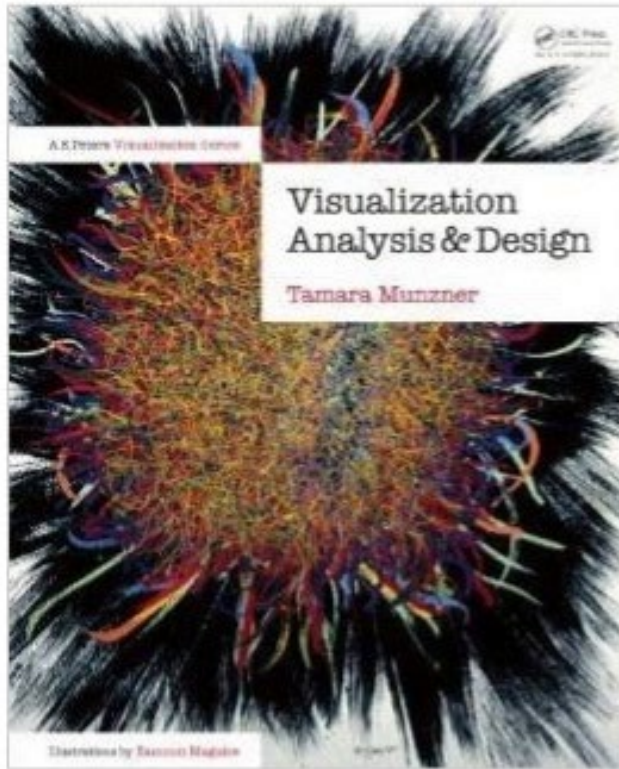
Visualization Analysis and Design

CRC Press, 2014

ISBN 1466508914

<http://www.cs.ubc.ca/~tmm/vadbook/>

Information Visualization: Textbook



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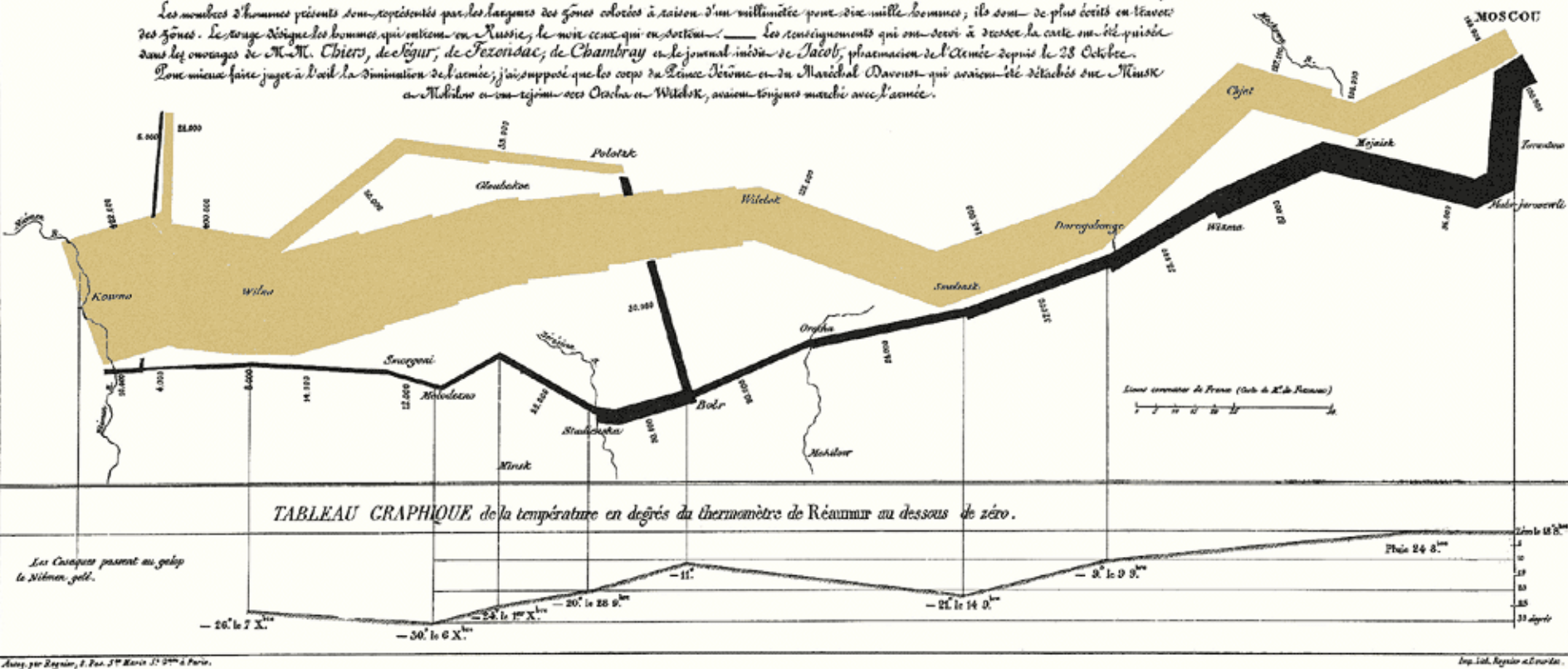
March 12, 12:30pm, Viz@UBC

Minard's Napoleon's 1812 March

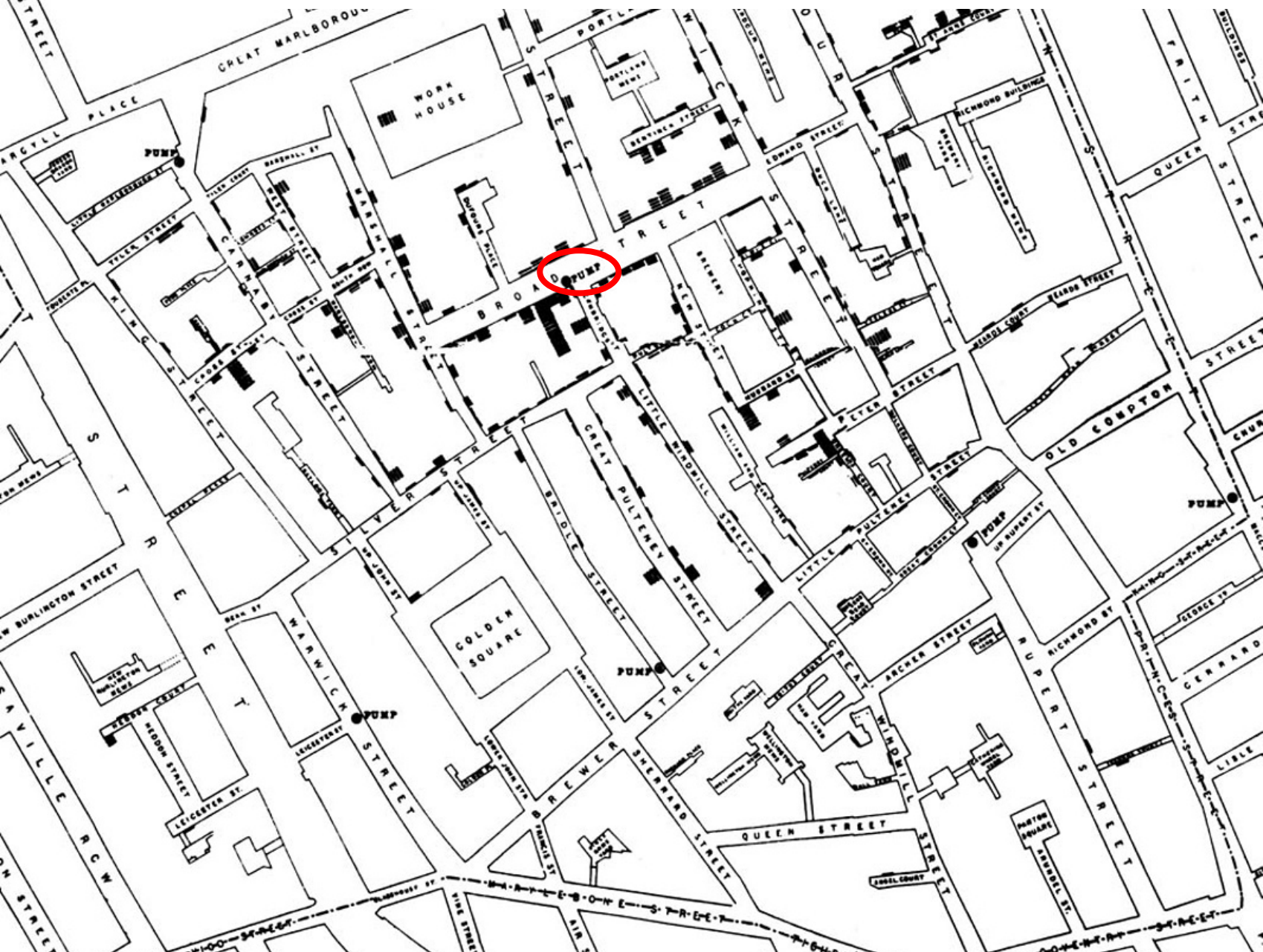
Carte Figurative des pertes successives en hommes de l'Armée Française dans la campagne de Russie 1812-1813.

Dessinée par M. Minard, Inspecteur Général des Ponts et Chaussées en retraite. Paris, le 20 Novembre 1869

Les nombres d'hommes présents sont représentés par les largeurs des zones colorées à raison d'un millimètre pour dix mille hommes; ils sont de plus écrits en lettres des zones. Le rouge désigne les hommes qui ont été en Russie, le noir ceux qui en sont sortis. Les renseignements qui ont servi à dresser la carte ont été puisés dans les ouvrages de M. M. Thiers, de Séguier, de Fozzardac, de Chambray et le journal inédit de Jacob, pharmacien de l'Armée depuis le 28 Octobre. Pour mieux faire juger à l'œil la diminution de l'armée, j'ai supposé que les corps de la Grande Armée en du Maréchal Davout qui avaient été détachés sur Minsk et Mielow et qui rejoignent Otscha et Wilna, avaient toujours marché avec l'armée.



John Snow's London Cholera May 1854



Information Visualization: Mantra

- Overview, zoom & filter, details-on-demand
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(The Eyes Have It, *IEEE VL*, 1996)



Information Visualization: Data Types

SciVis

- **1-D Linear** Document scrolling/panning
- **2-D Map** Maps & Medical imagery
- **3-D World** CAD, Medical, Molecules, Architecture

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- **Temporal** EventFlow, TimeSearcher, Palantir, DataMontage
- **Tree** Node-link, Nested-Indented, Treemap
- **Network** Pajek, UCINET, NodeXL, Gephi, Tom Sawyer
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flowingdata.com

eagereyes.org

visualisingdata.com

informationisbeautiful.net

perceptualedge.com



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perceptualedge.com

<https://mdl.library.utoronto.ca/dataviz/getting-started>



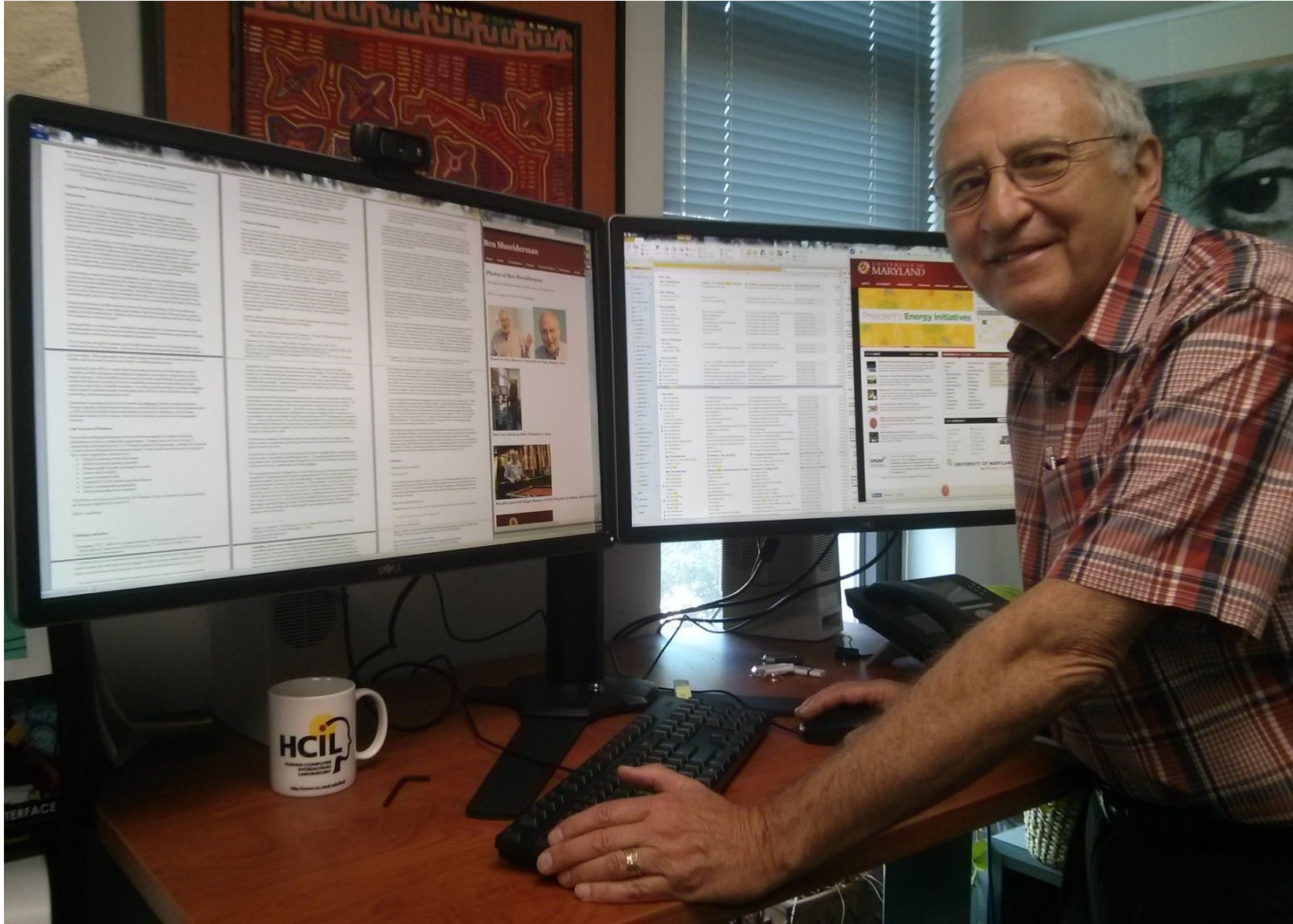
10M - 100M pixels: Large displays



Innovations for Global MBA program



16M pixels: My Workstation

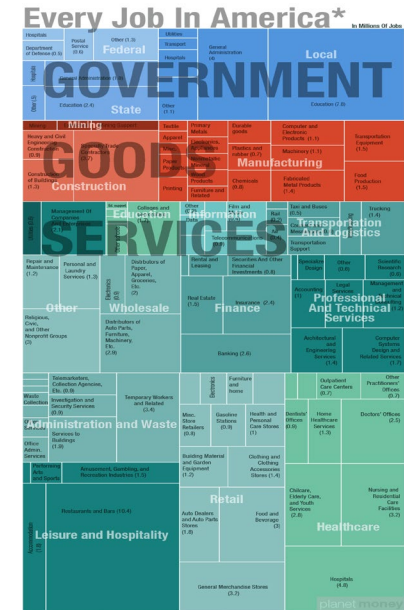
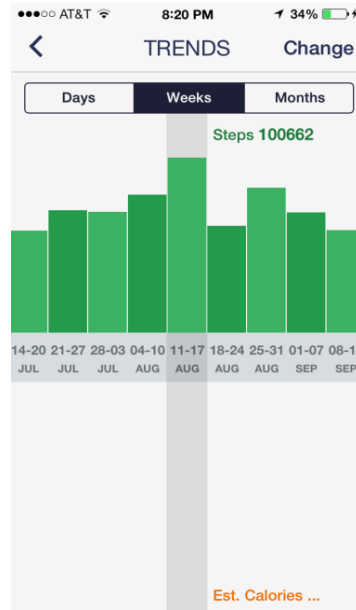
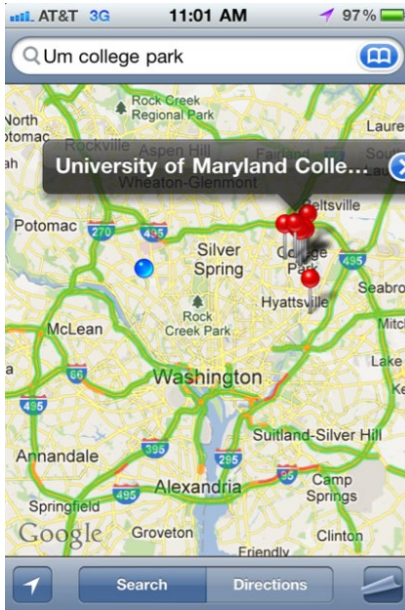


100M-pixels & more



1M-pixels & less

Small mobile devices



**The purpose of
visualization
is insight,
not pictures**

Anscombe's Quartet

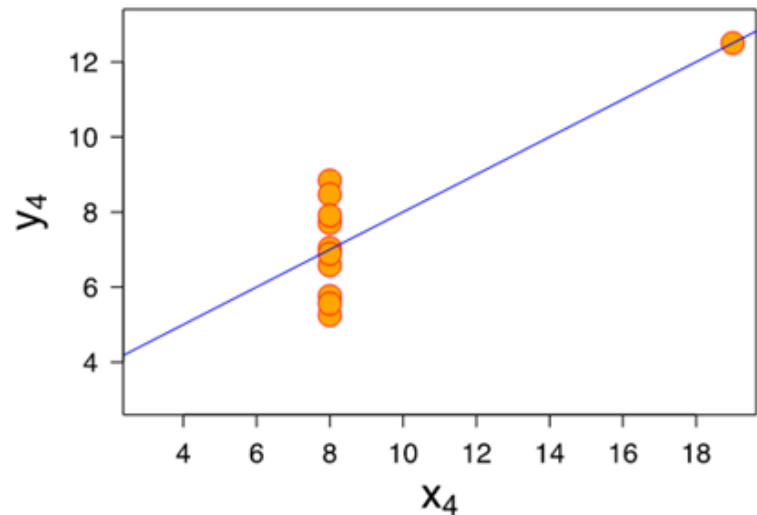
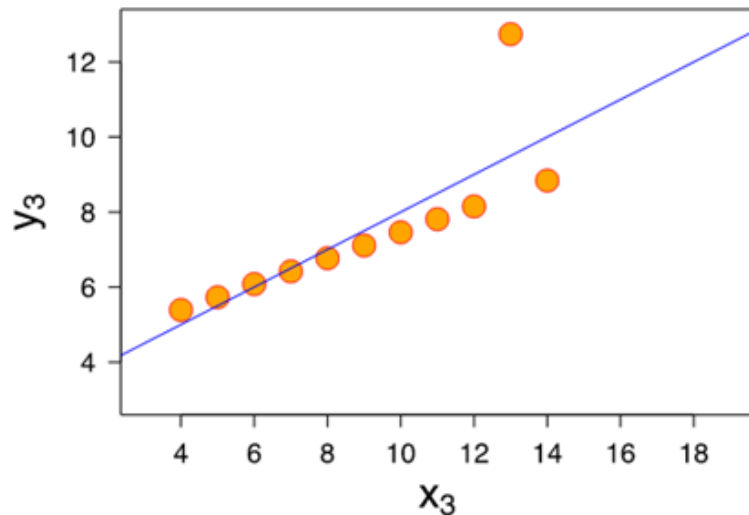
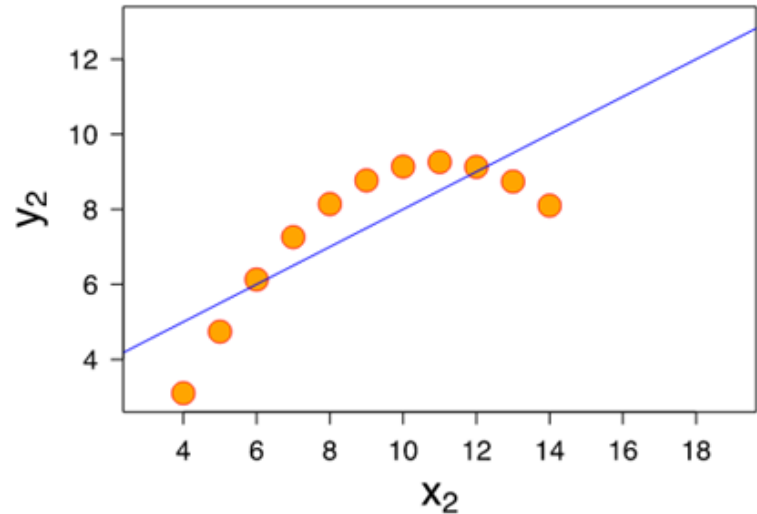
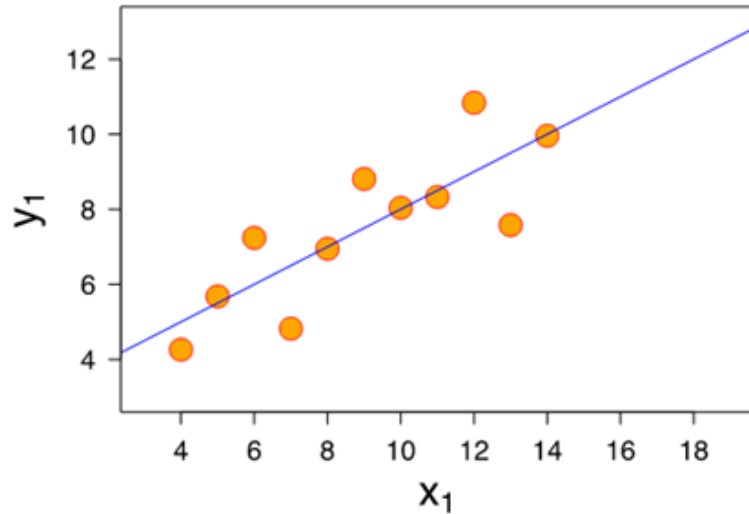
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x	y	x	y	x	y	x	y
10.0	8.04	10.0	9.14	10.0	7.46	8.0	6.58
8.0	6.95	8.0	8.14	8.0	6.77	8.0	5.76
13.0	7.58	13.0	8.74	13.0	12.74	8.0	7.71
9.0	8.81	9.0	8.77	9.0	7.11	8.0	8.84
11.0	8.33	11.0	9.26	11.0	7.81	8.0	8.47
14.0	9.96	14.0	8.10	14.0	8.84	8.0	7.04
6.0	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

Anscombe's Quartet

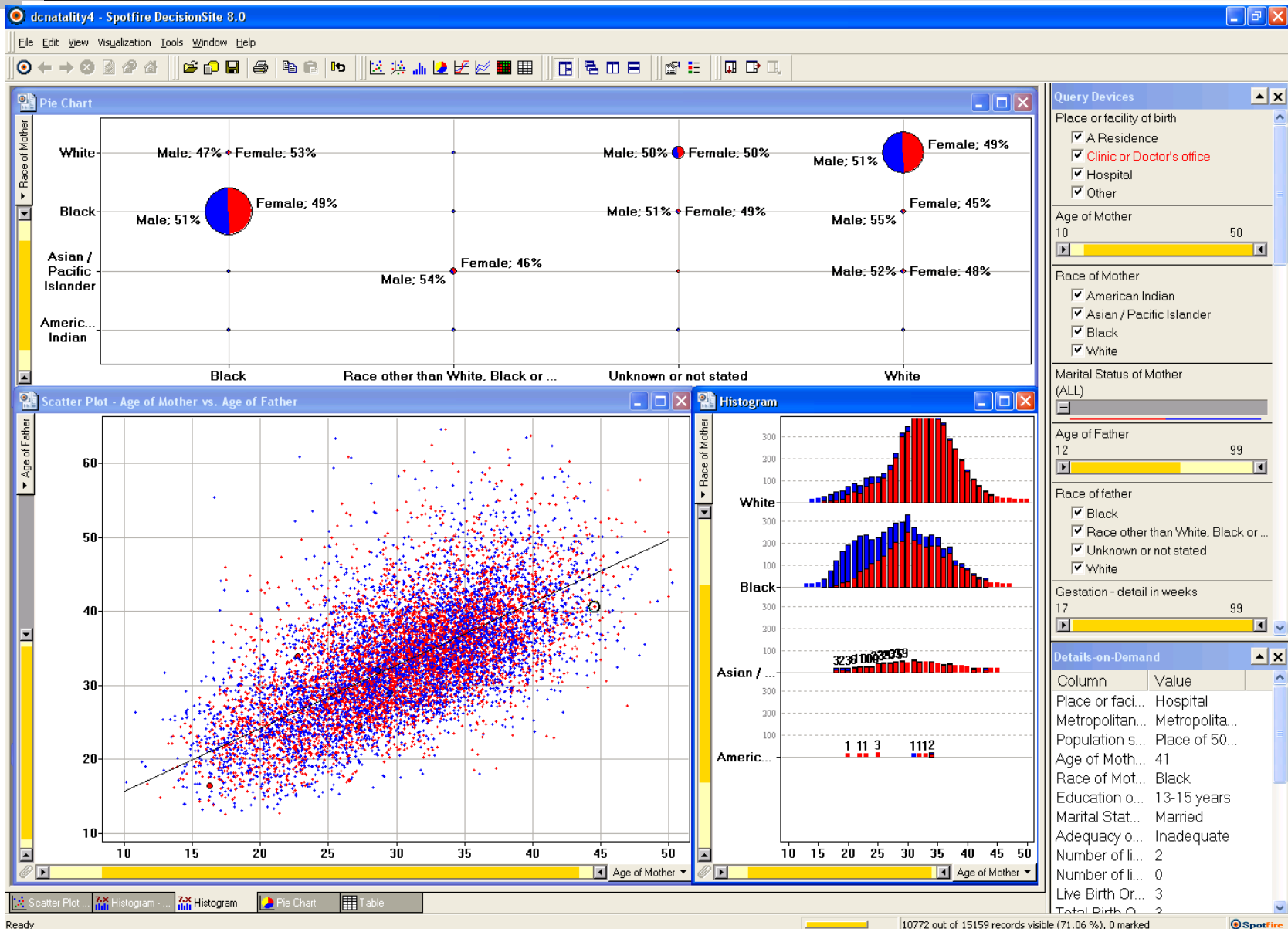
1		2		3		4	
x	y	x	y	x	y	x	y
10.0	8.04	10.0	9.14	10.0	7.46	8.0	6.58
8.0	6.95	8.0	8.14	8.0	6.77	8.0	5.76
13.0	7.58	13.0	8.74	13.0	12.74	8.0	7.71
9.0	8.81	9.0	8.77	9.0	7.11	8.0	8.84
11.0	8.33	11.0	9.26	11.0	7.81	8.0	8.47
14.0	9.96	14.0	8.10	14.0	8.84	8.0	7.04
6.0	7.24	6.0	6.13	6.0	6.08	8.0	5.25
4.0	4.26	4.0	3.10	4.0	5.39	19.0	12.50
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Property	Value
Mean of x	9.0
Variance of x	11.0
Mean of y	7.5
Variance of y	4.12
Correlation	0.816
Linear regression	$y = 3 + 0.5x$

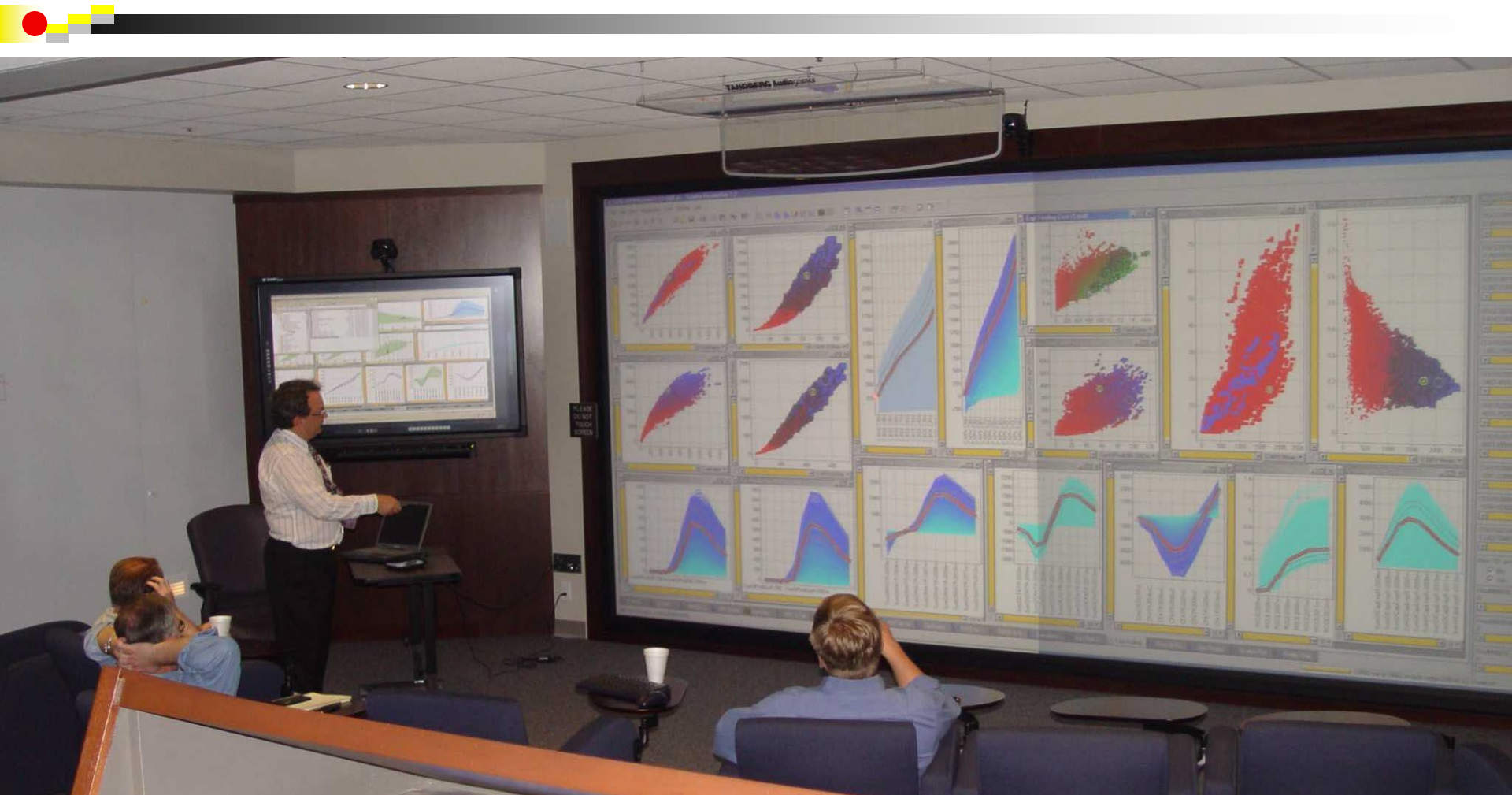
Anscombe's Quartet



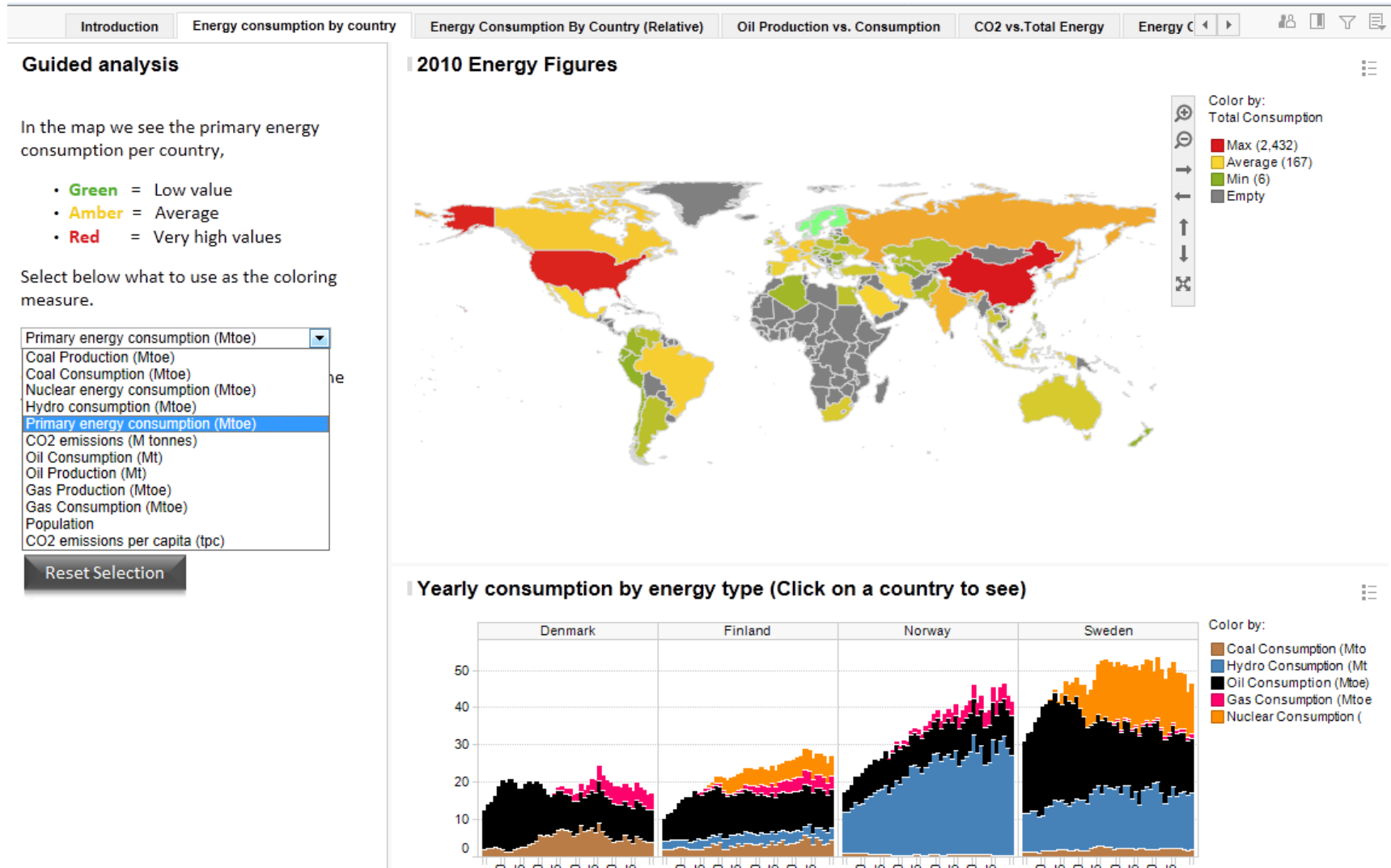
Spotfire: DC natality data





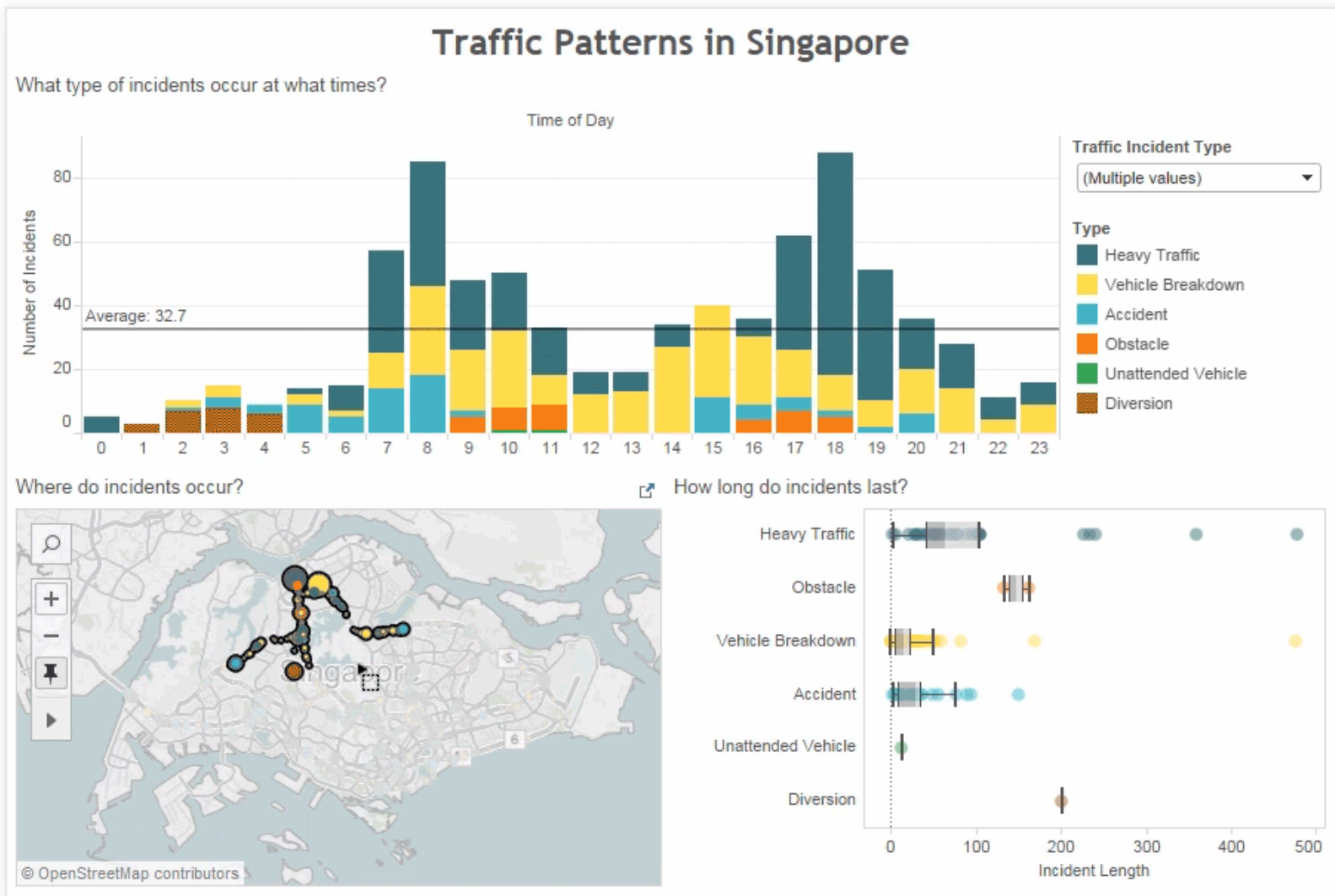


Spotfire web demo



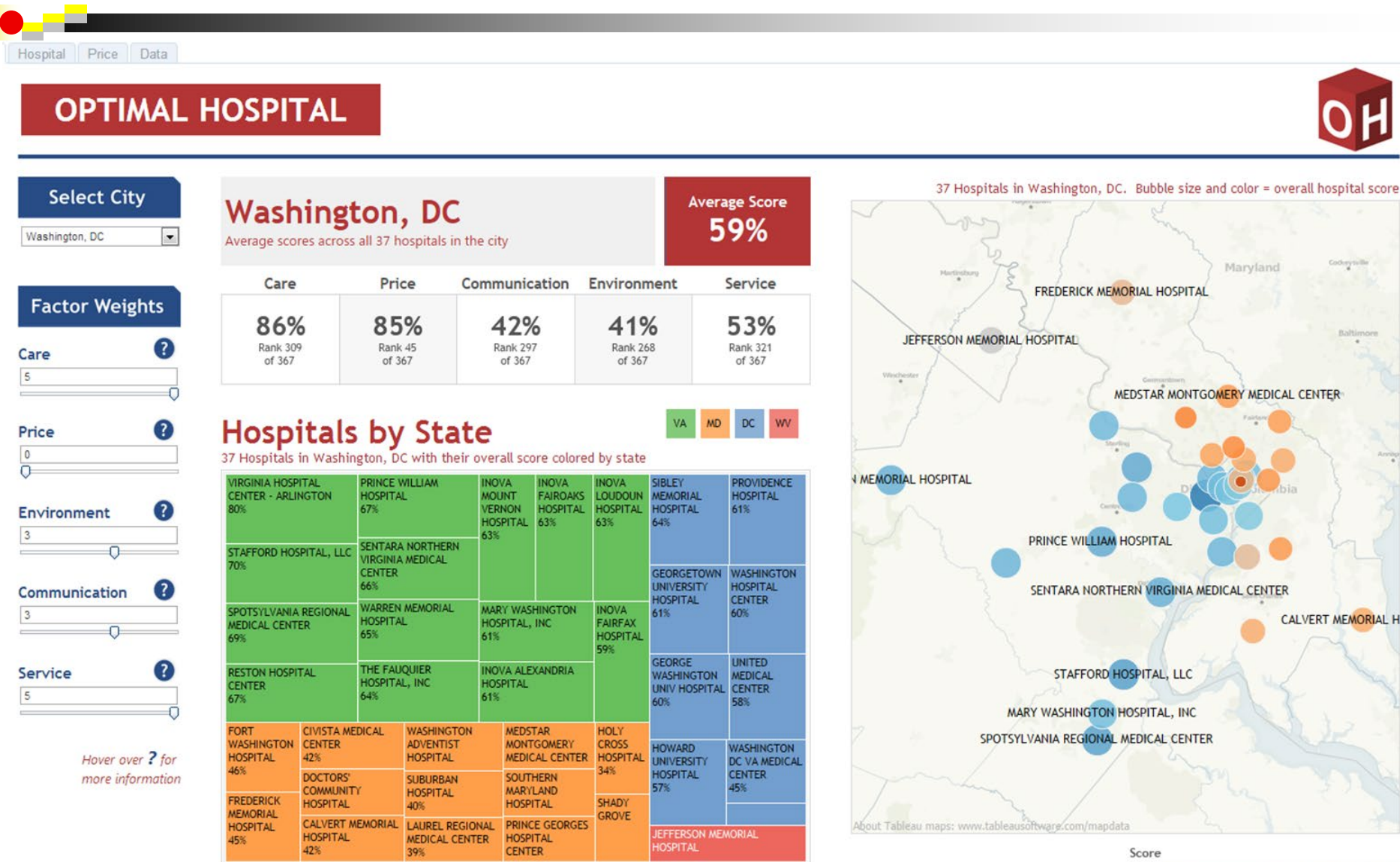
<http://spotfire.tibco.com/en/demos/world-energy-survey.aspx>

Tableau: Singapore Traffic Data



<http://www.tableau.com/products/desktop#video>

Tableau: RWJF Hospital Analysis



Multi-Variate: Race in Schools

There are large gaps between white children and their black and Hispanic classmates. The gaps are largest in places with large economic disparities.

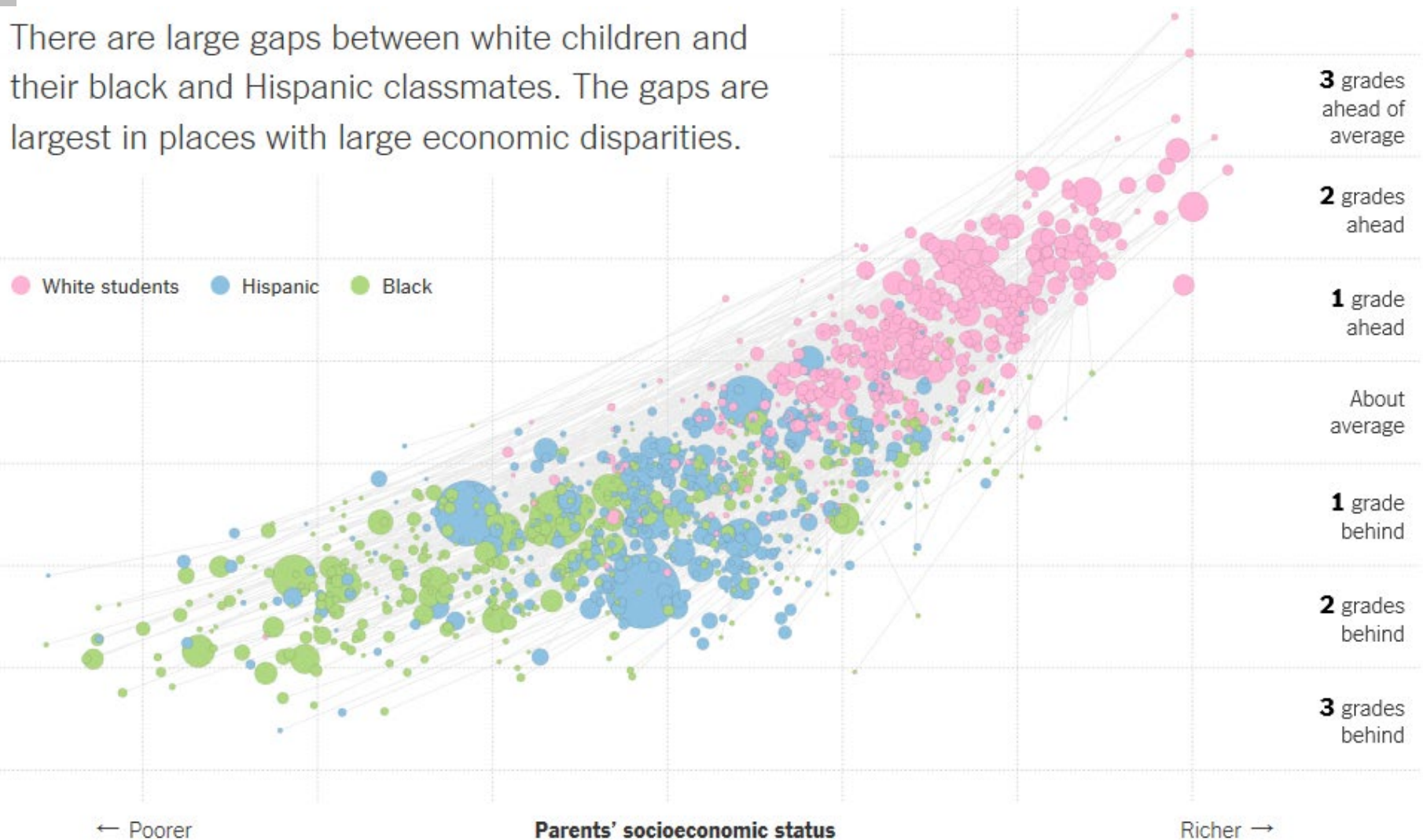


Chart shows districts with at least 100 white, 100 black and 100 Hispanic students per grade. Reliable estimates are not available for Asian-Americans.





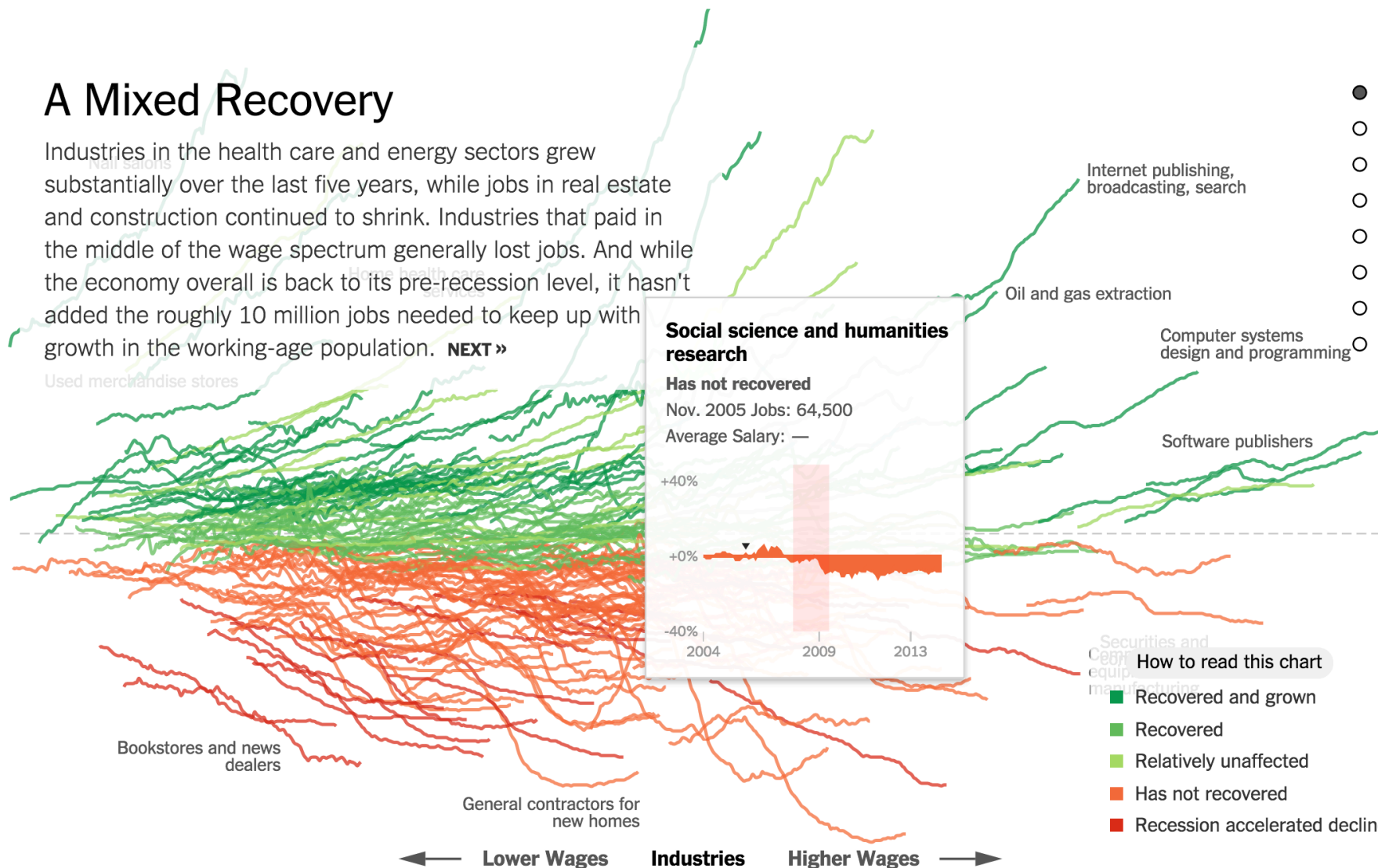
A Mixed Recovery

Industries in the health care and energy sectors grew substantially over the last five years, while jobs in real estate and construction continued to shrink. Industries that paid in the middle of the wage spectrum generally lost jobs. And while the economy overall is back to its pre-recession level, it hasn't added the roughly 10 million jobs needed to keep up with growth in the working-age population. **NEXT »**

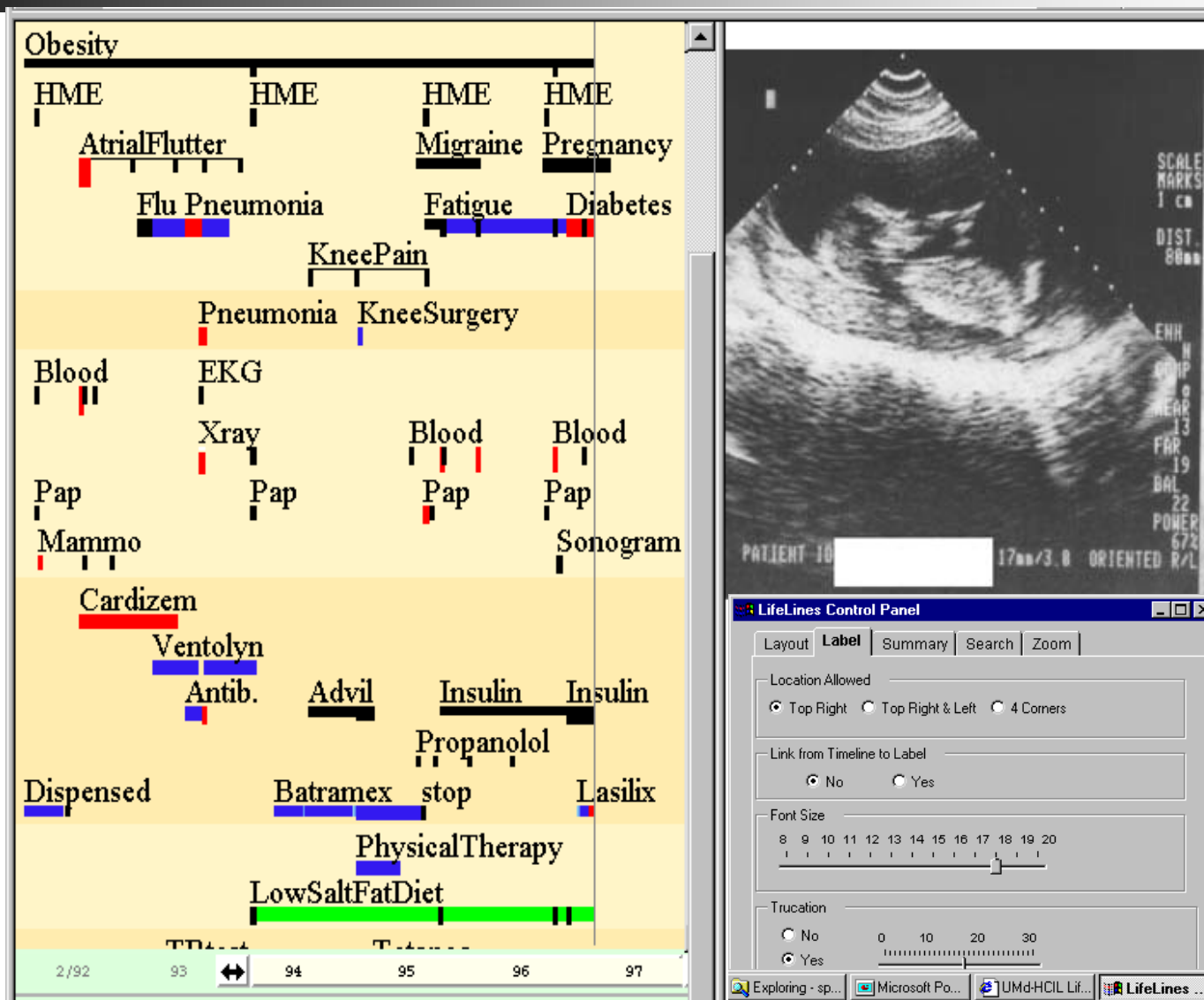
Increased

Jobs since recession

Decreased

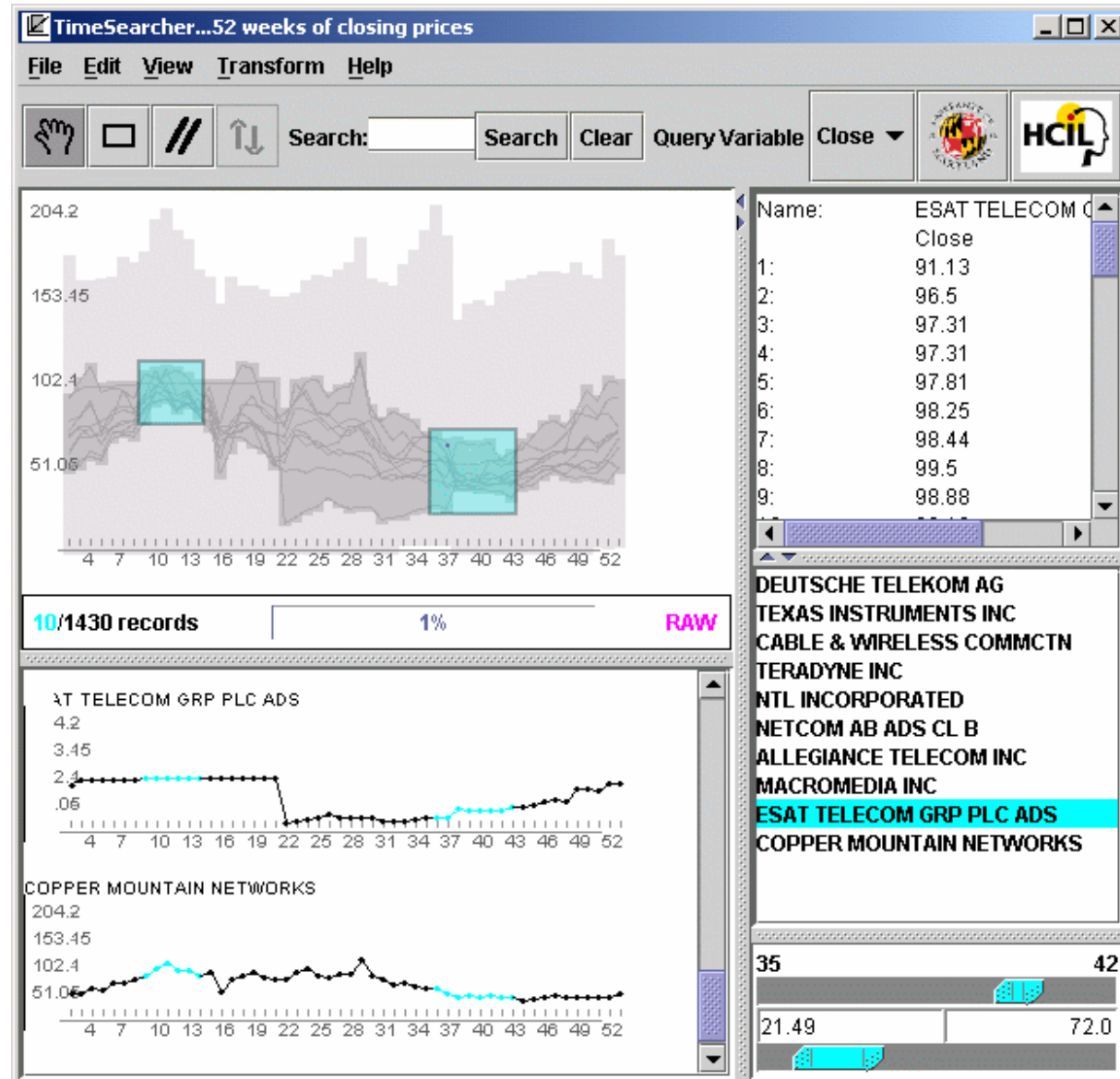


LifeLines: Patient Histories



Temporal Data: TimeSearcher 1.3

- Time series
 - Stocks
 - Weather
 - Genes
- User-specified patterns
- Rapid search



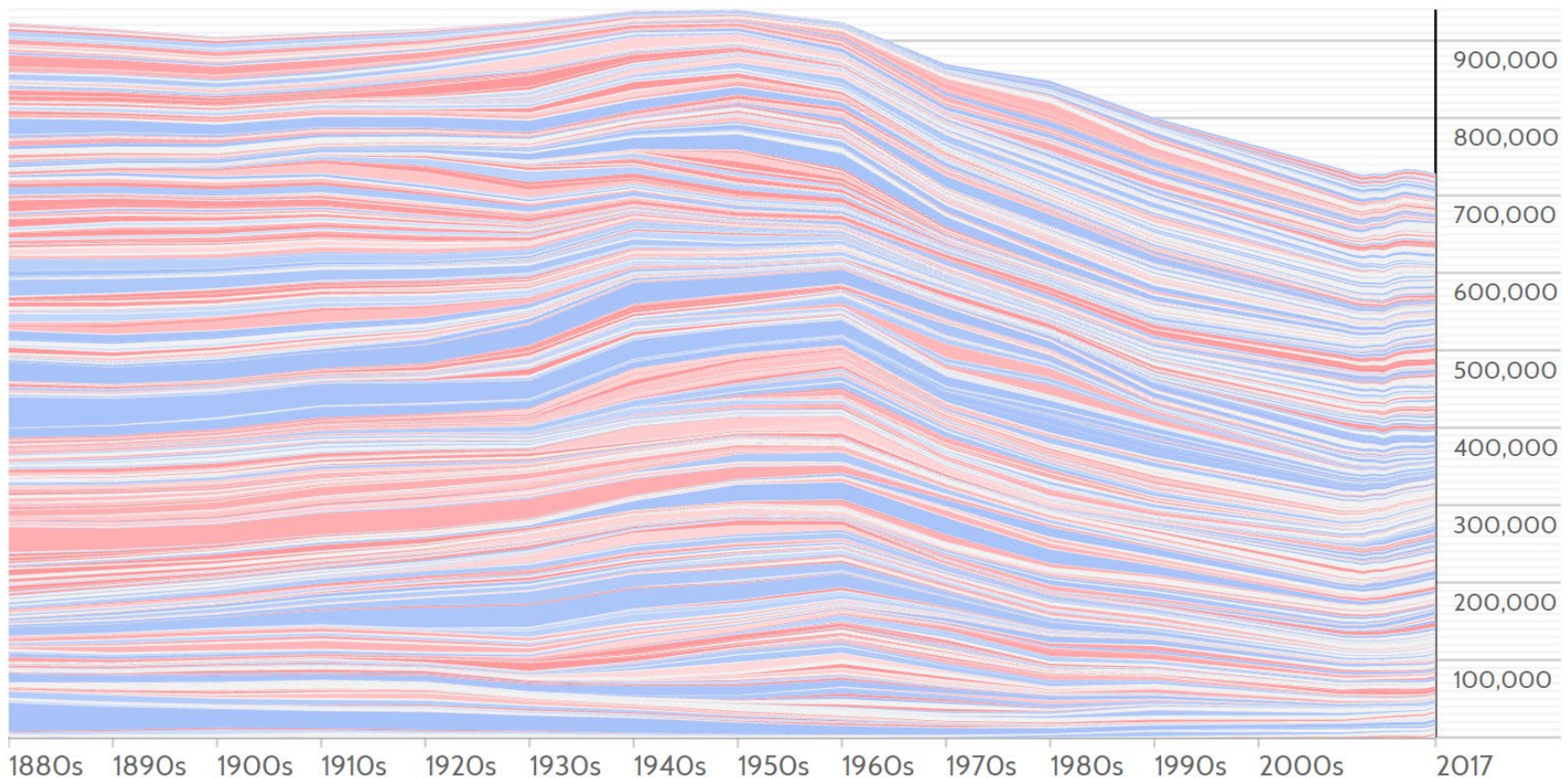
Baby Name Voyager: Time Series

- 1000 most popular names for children for each census from 1880

What questions might you ask?

Baby Name Voyager: Time Series

- 1000 most popular names for children for each census from 1880



<http://www.babynamewizard.com/voyager>

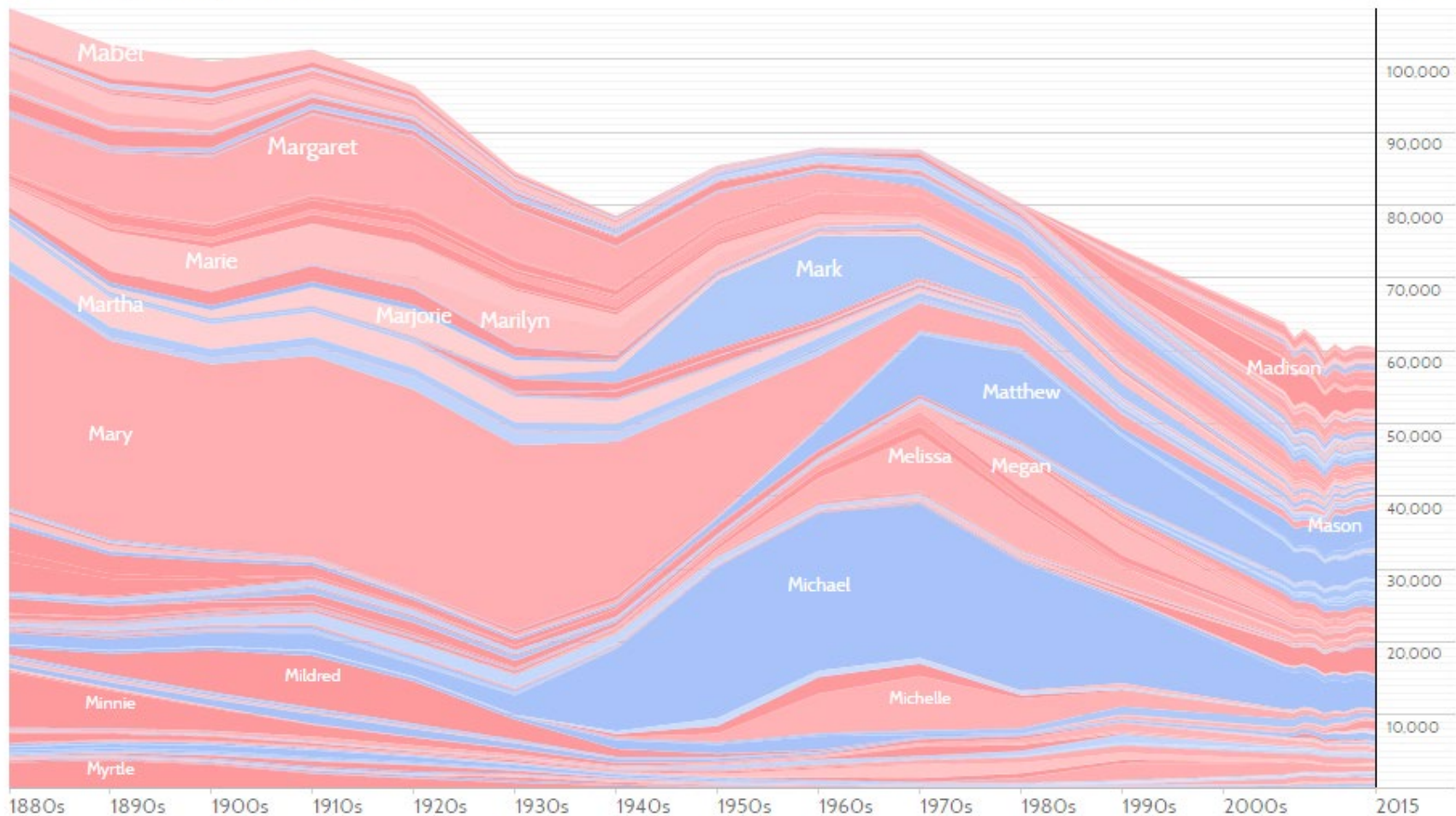


Baby Name Voyager: Time Series

Baby Name > ☒ Both ☐ Boys ☐ Girls

Current rank: boys 1000 500 100 25 1 girls 1000 500 100 25 1 per million births

Names starting with 'M' per million babies



<http://www.babynamewizard.com/voyager>



Treemap: NY Times – Car&Truck Sales

The New York Times > Business > Image > Truck Sales Slip, Tripping Up Chrysler - Internet Explorer provided by Dell
http://www.nytimes.com/imagepages/2007/02/25/business/20070225_CHRYSLER_GRAPHIC.html

The New York Times

February 25, 2007

Truck Sales Slip, Tripping Up Chrysler

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

READING THE CHART

Boxes are scaled proportionally according to number of cars sold in 2006



Change in sales from 2005 to 2006



Many of these vehicles were introduced in 2005.

SALES CHANGE
05 TO '06

Chrysler Group **-7.0%**
 Trucks/vans/S.U.V.'s 1.6 million
 Cars 0.5 million

Pickups, minivans and S.U.V.'s made up 76 percent of Chrysler's sales, which left it vulnerable when consumers shifted to cars.



General Motors **-8.7%**
 Trucks/vans/S.U.V.'s 2.5 million
 Cars 1.6 million

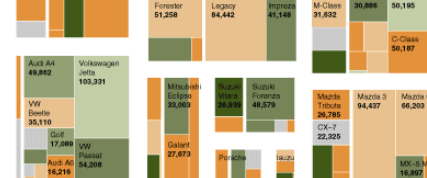
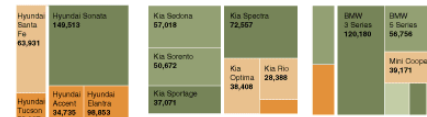
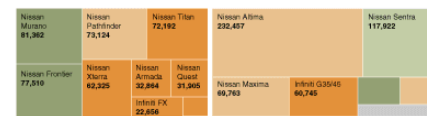
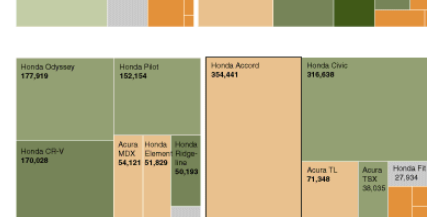
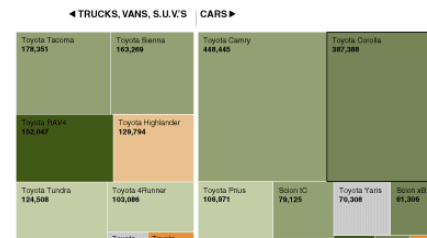
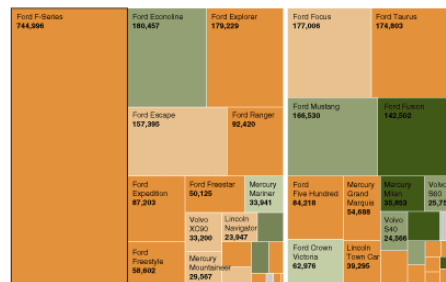
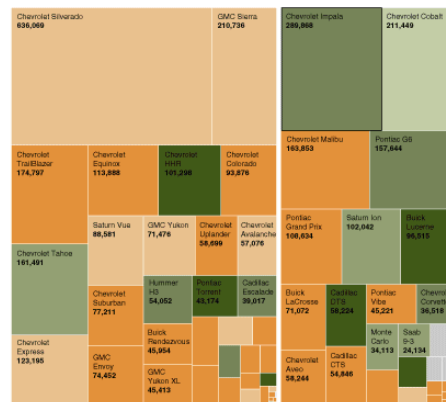
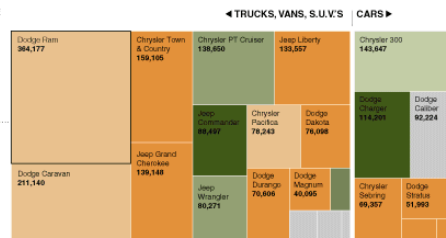
G.M. introduced new versions of its large S.U.V.'s in late 2005, hoping they would bolster sales. Instead, sales of big vehicles were hurt when gas prices climbed. One of the few standouts was the Chevrolet HHR, new in 2005.



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

Ford **-8.3%**
 Trucks/vans/S.U.V.'s 1.8 million
 Cars 1.1 million

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



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

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



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

Honda **+3.2%**
 Trucks/vans/S.U.V.'s 0.7 million
 Cars 0.8 million

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



Nissan **-5.3%**
 Trucks/vans/S.U.V.'s 0.5 million
 Cars 0.6 million

BMW **+2.1%**
 Trucks/vans/S.U.V.'s 0.1 million
 Cars 0.3 million

Mercedes-Benz **+10.3%**
 Trucks/vans/S.U.V.'s 0.1 million
 Cars 0.2 million

Mercedes-Benz, owned by DaimlerChrysler, had a comeback in 2006, thanks to a new version of its flagship S-Class. BMW sales were helped by a new Truck Sales Slip, 1 Series sport sedan.

Sources: Ward's AutoInfoBank; Edmunds

Amanda Cox and Hannah Fairfield/The New York Times



FinViz: Mixed day, July 30, 2015



<https://finviz.com/map.ashx>





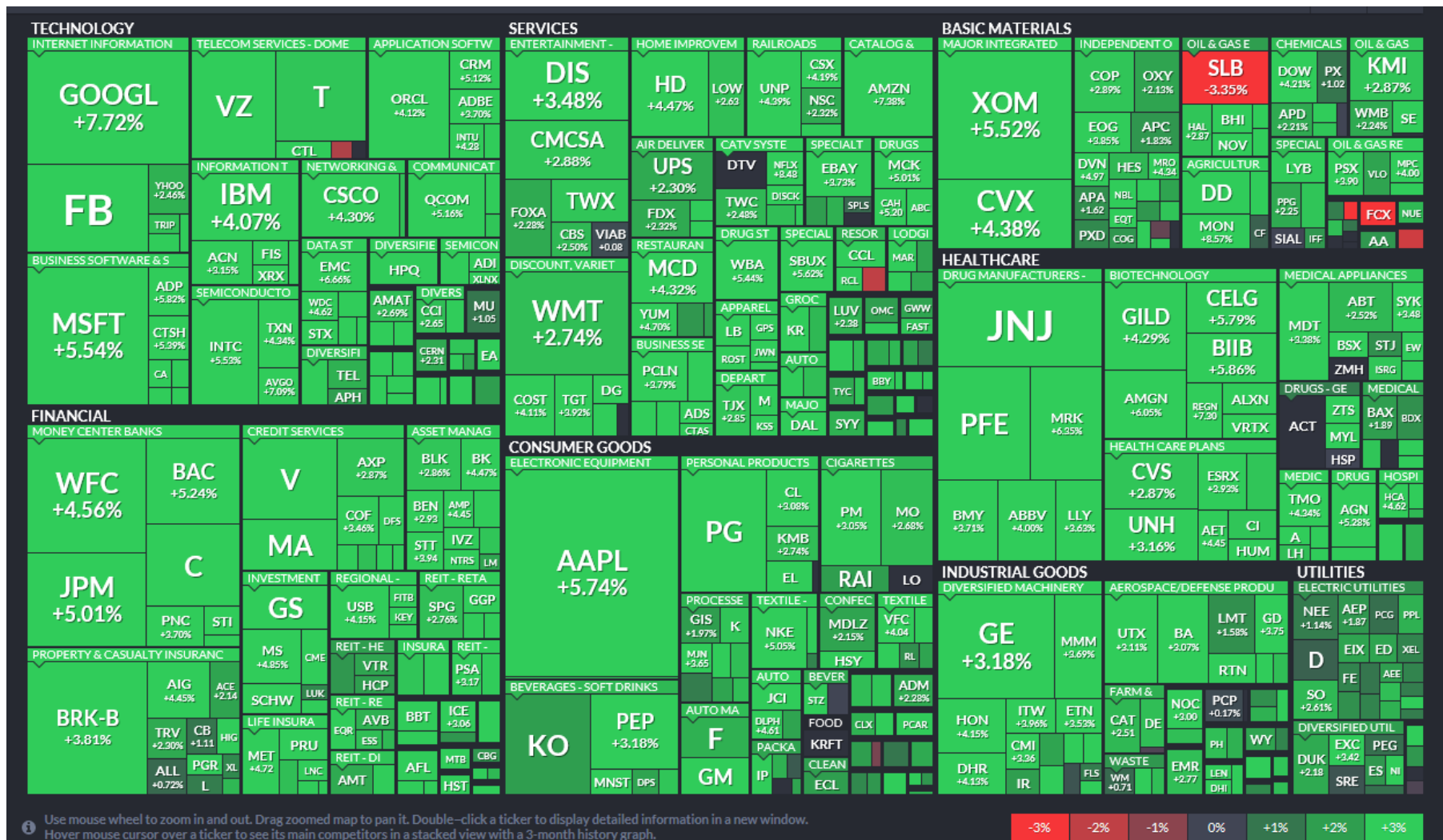
FinViz: Better day, August 25, 2015



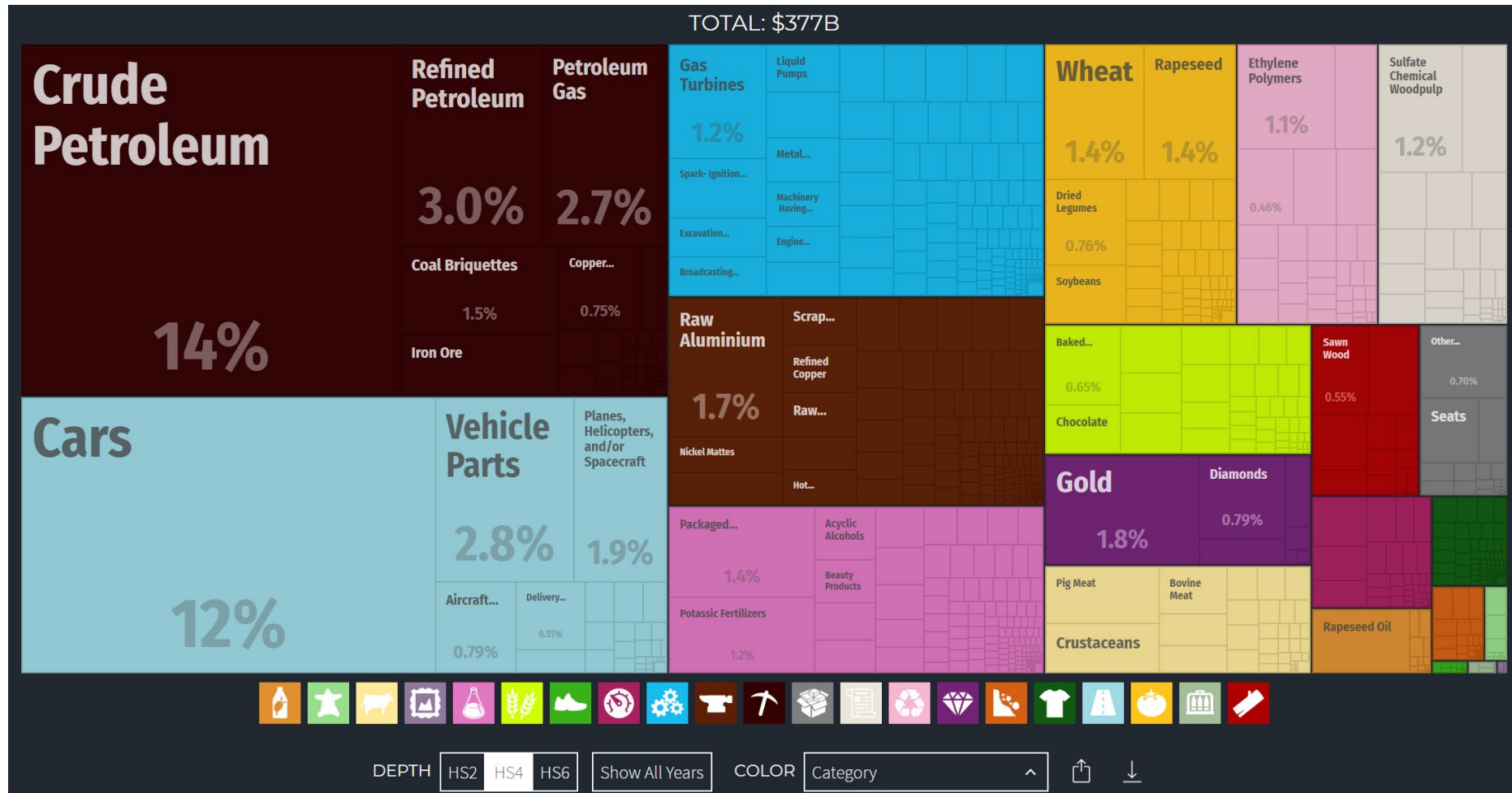
Use mouse wheel to zoom in and out. Drag zoomed map to pan it. Double-click a ticker to display detailed information in a new window. Hover mouse cursor over a ticker to see its main competitors in a stacked view with a 3-month history graph.

-3% -2% -1% 0% +1% +2% +3%

FinViz: Good day, August 26, 2015

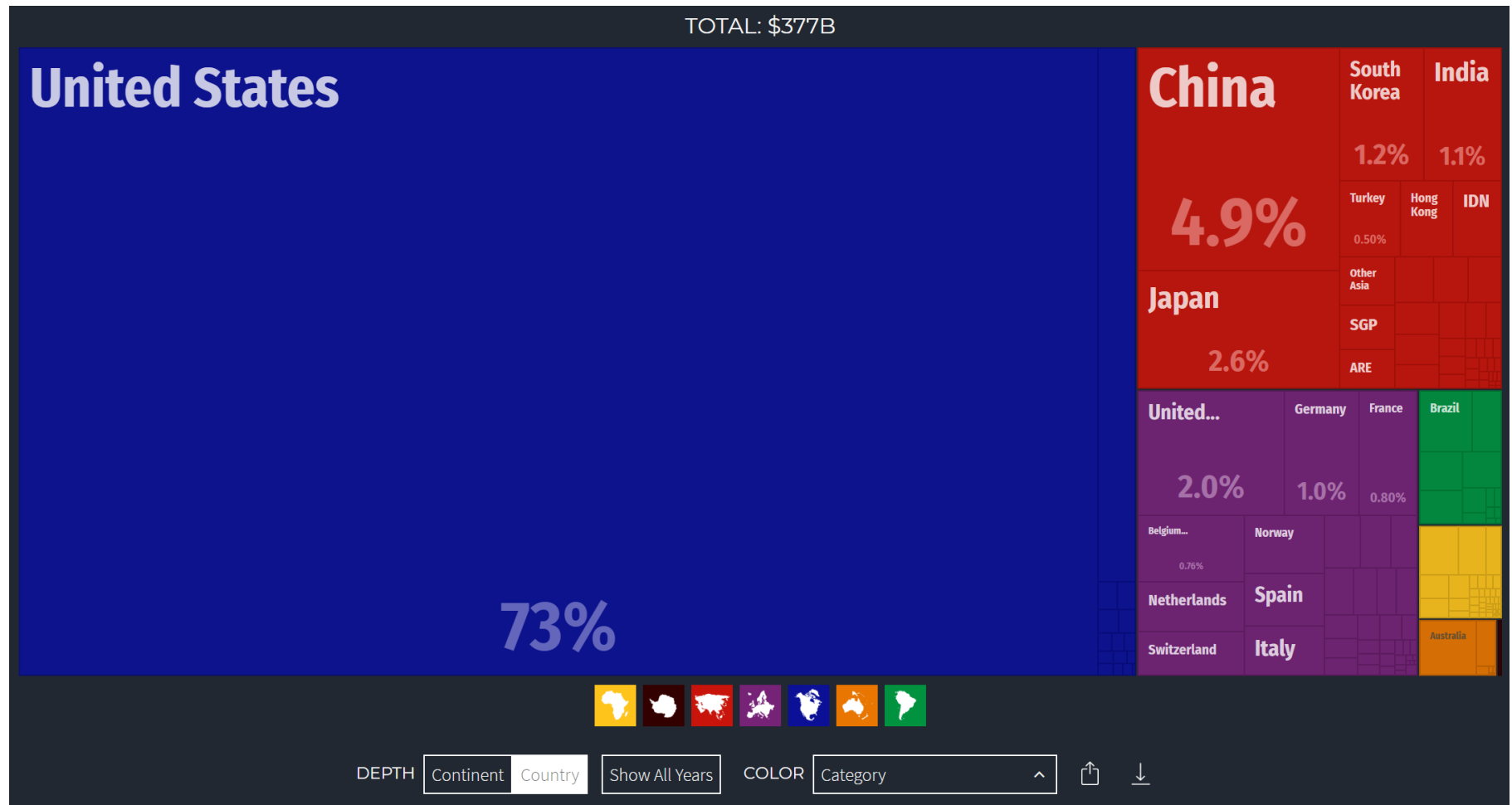


Canada Exports: Products



<https://atlas.media.mit.edu/en/profile/country/can/>

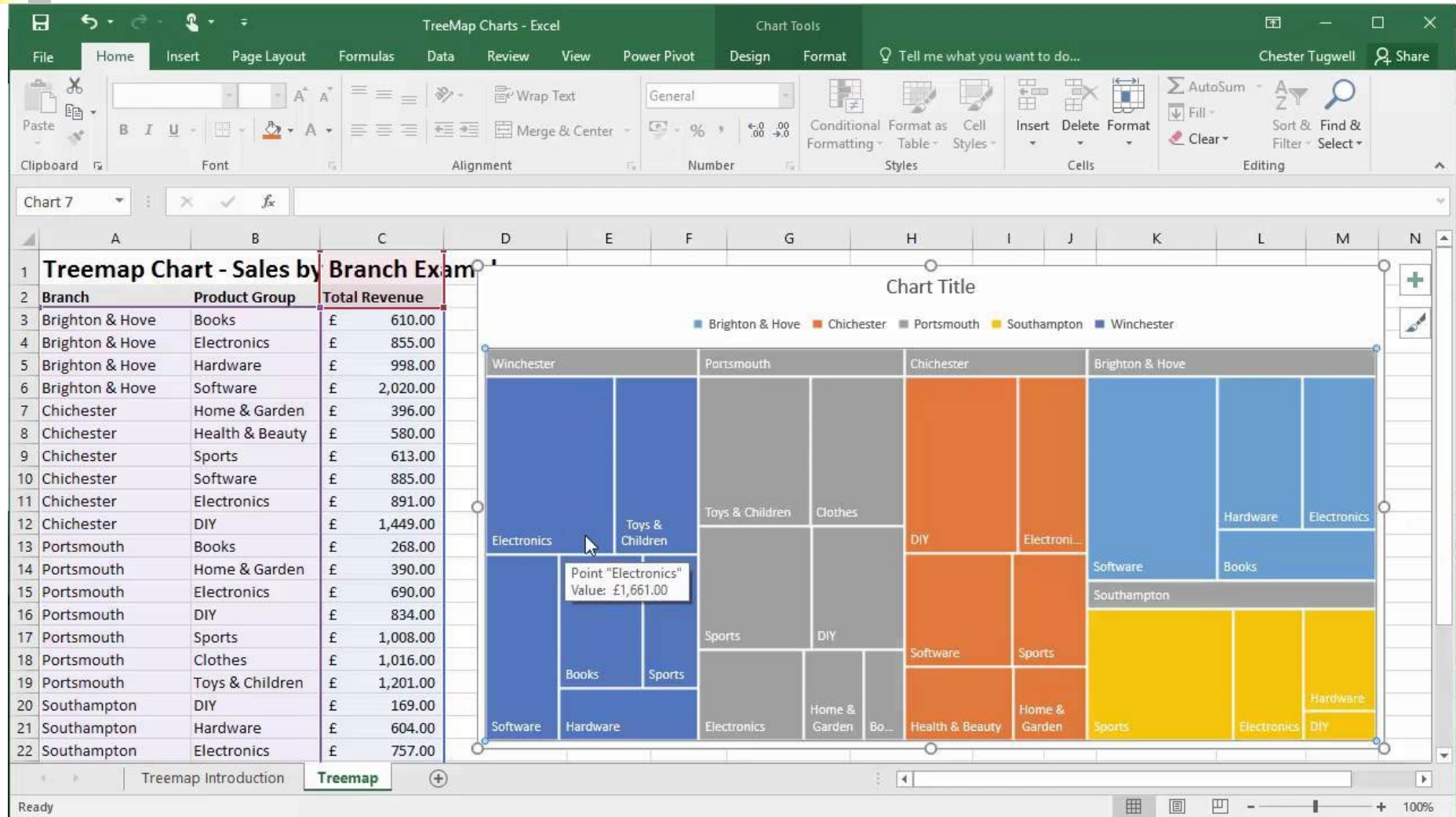
Canada Exports: Destinations



<https://atlas.media.mit.edu/en/profile/country/can/>

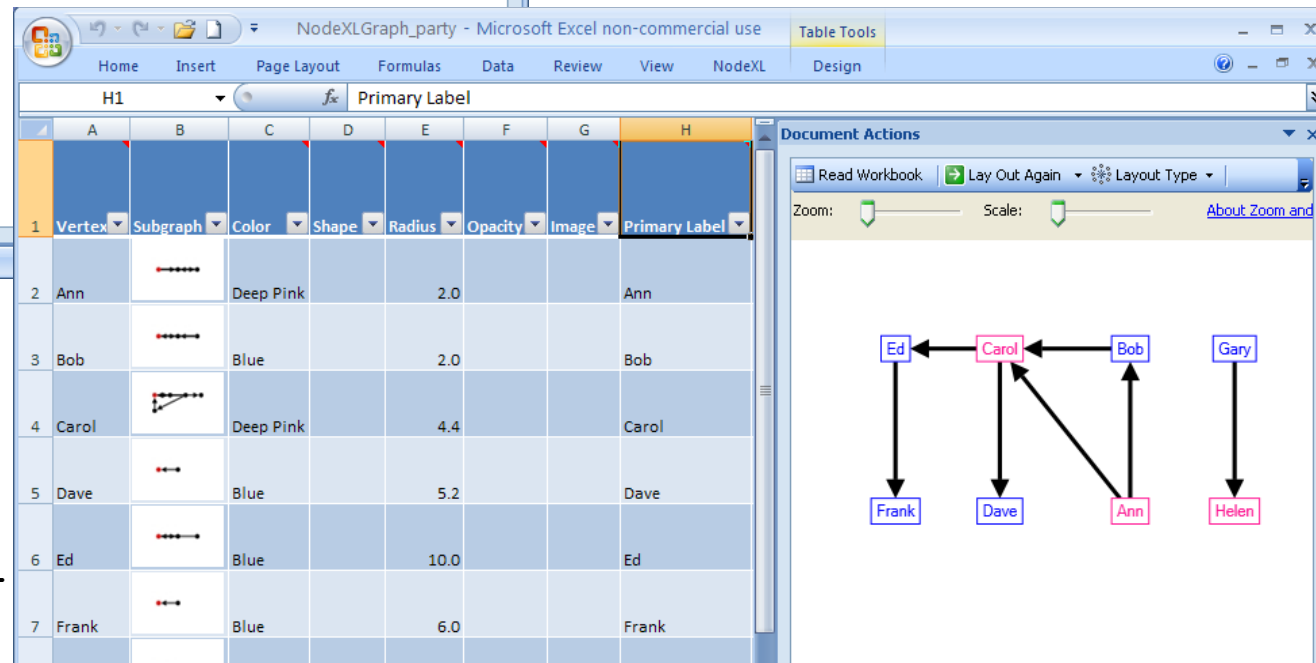
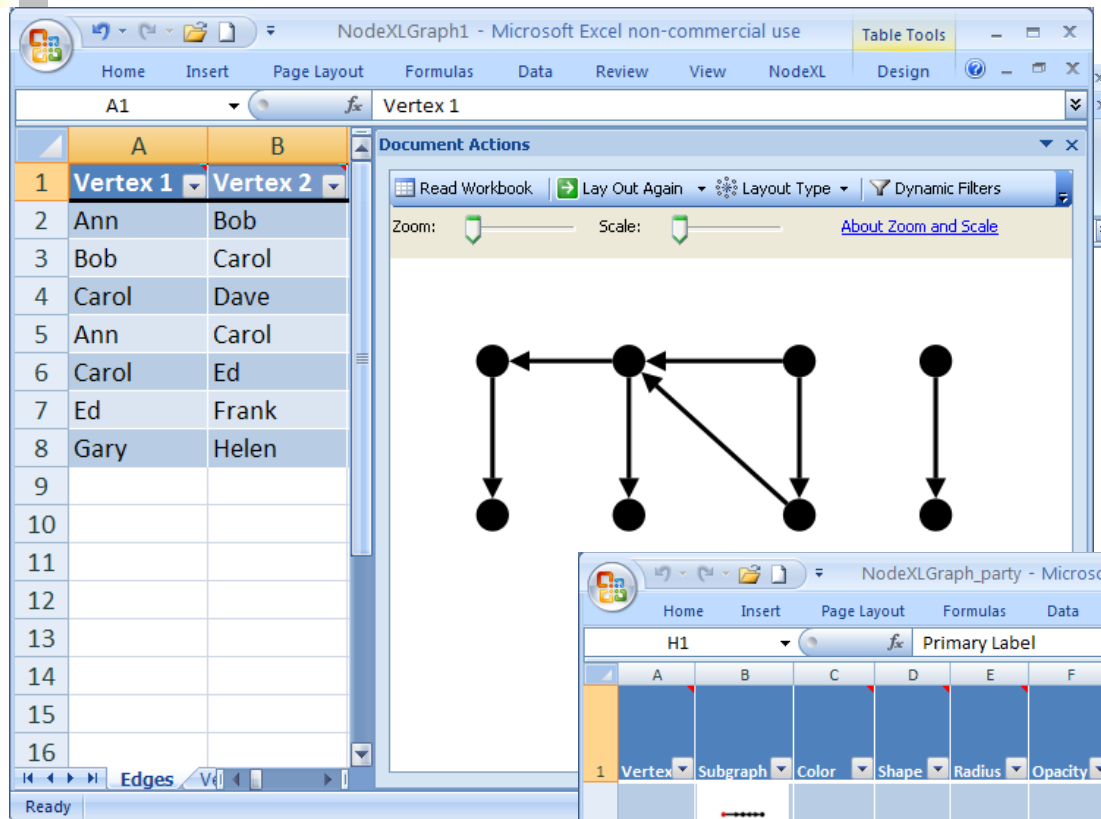


Excel includes treemaps, 2014



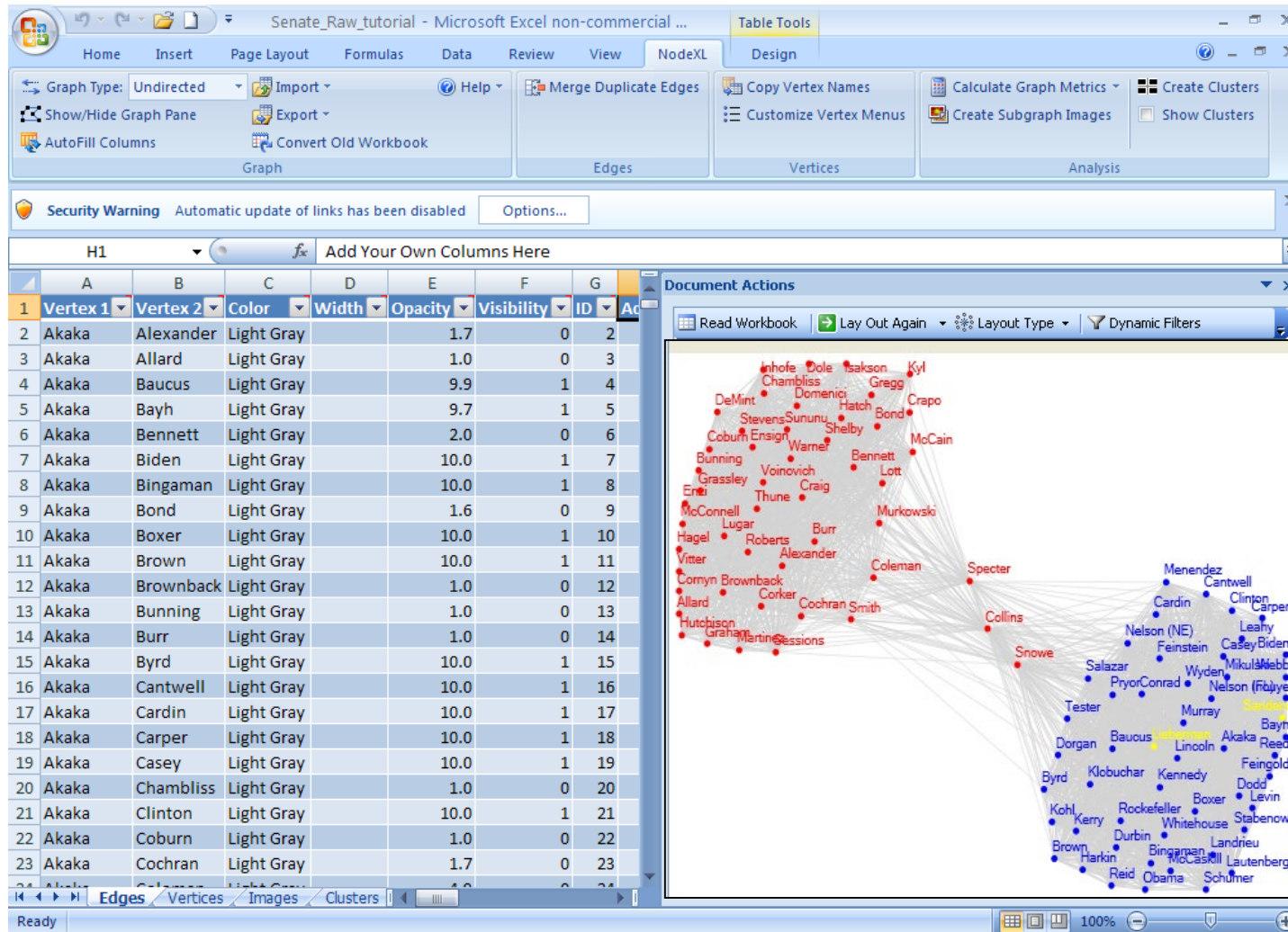
NodeXL:

Network Overview for Discovery & Exploration in Excel

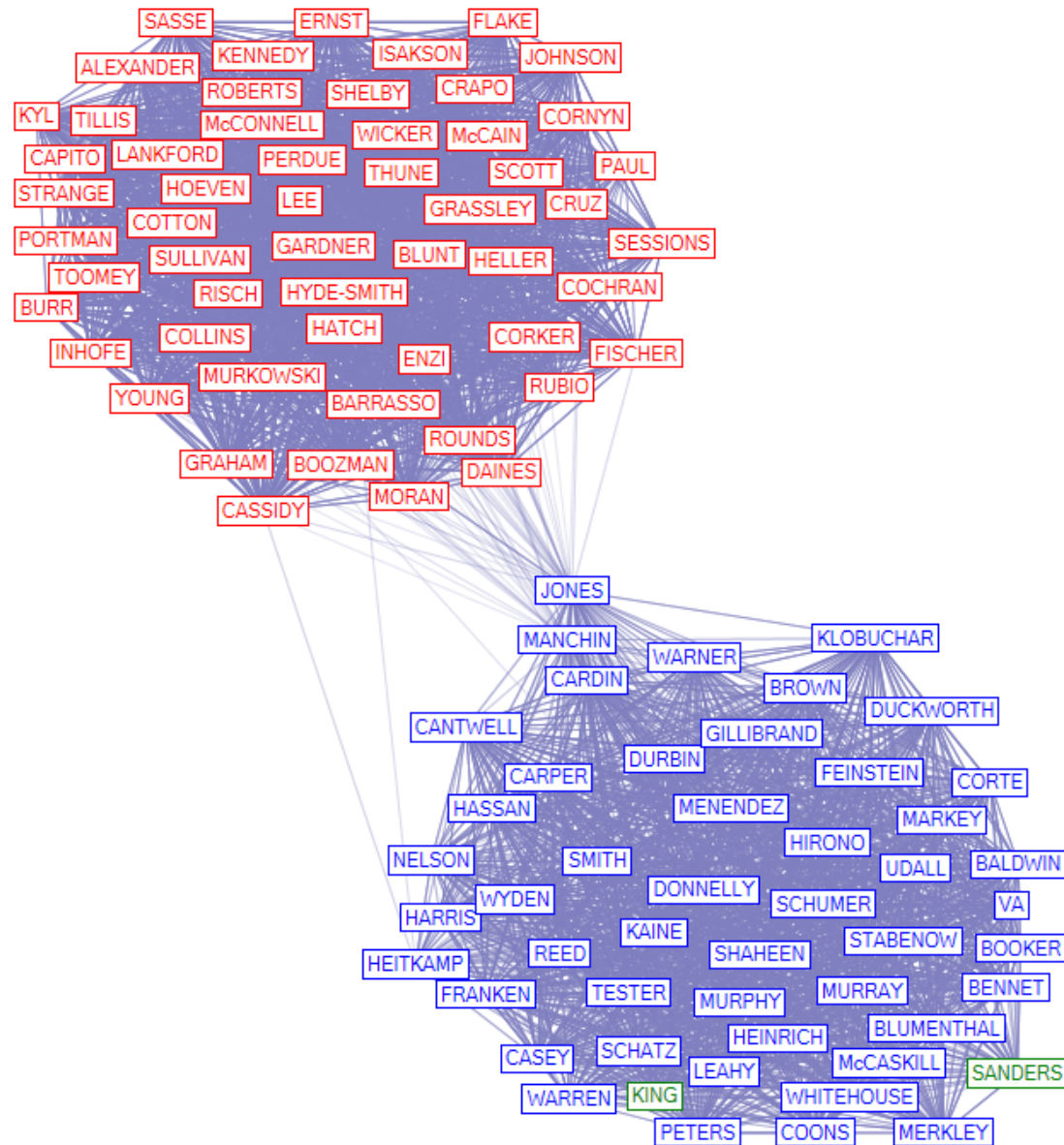


NodeXL:

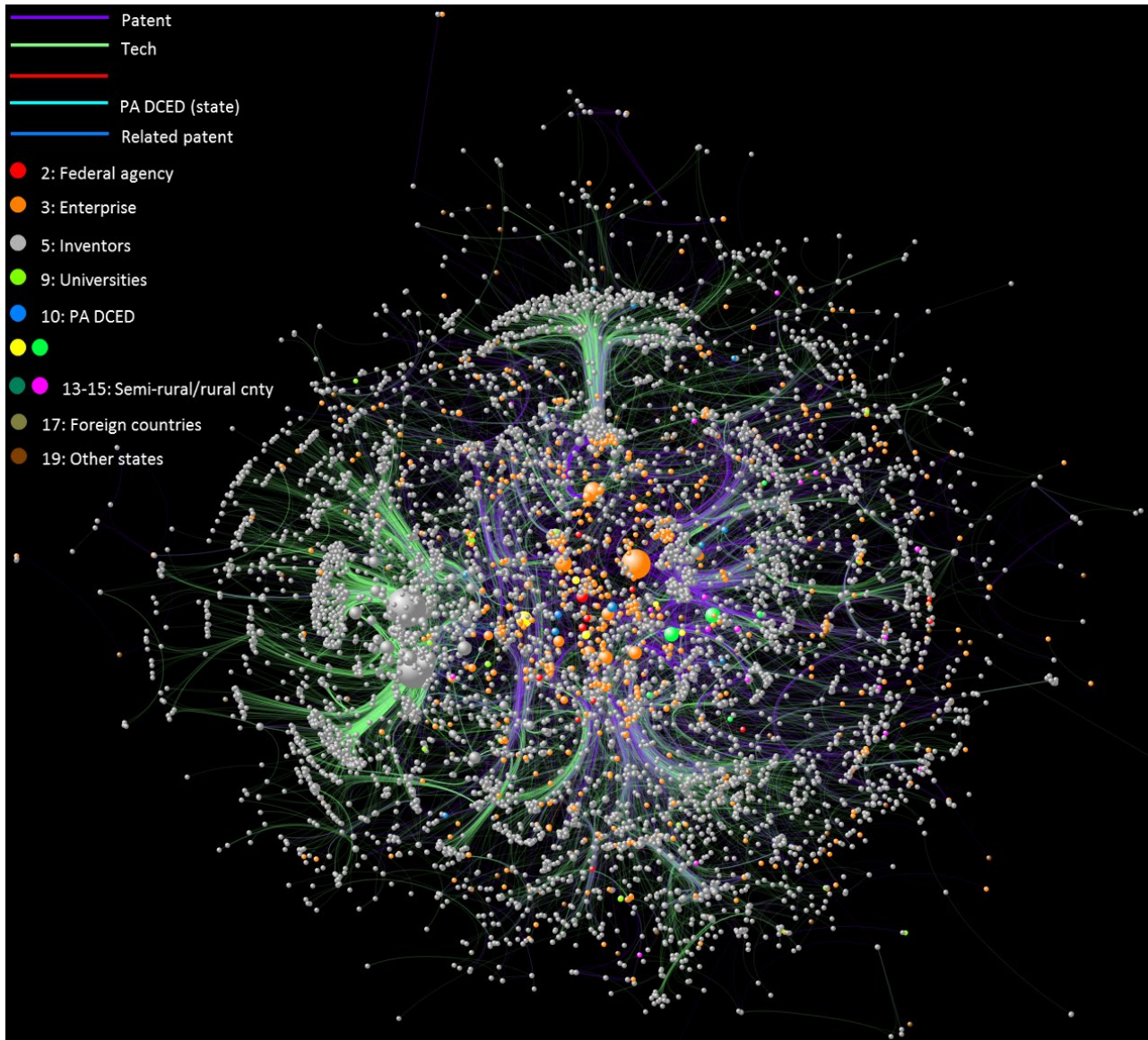
Network Overview for Discovery & Exploration in Excel



2017-18 U.S. 115th Senate co-voting network

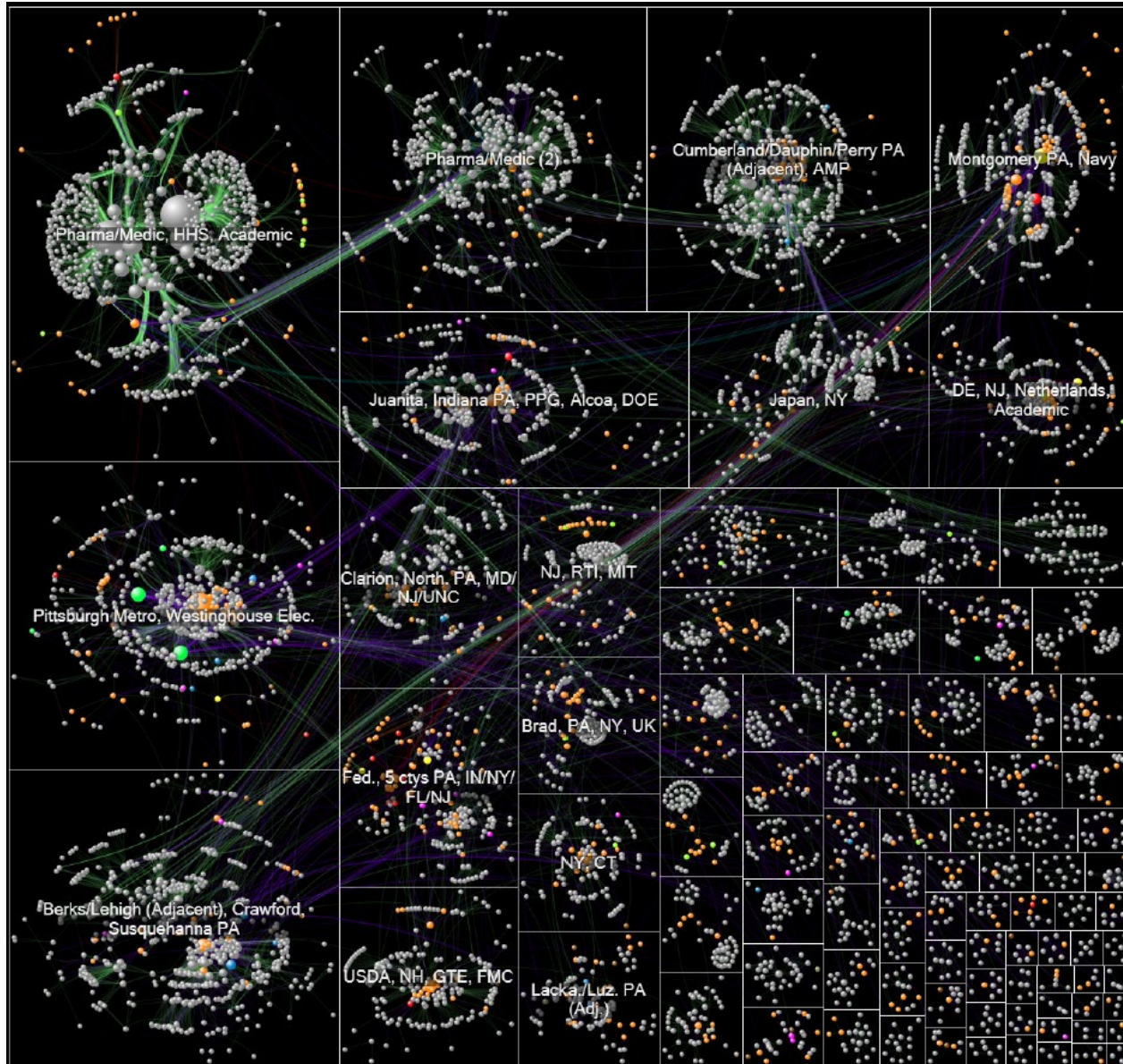


Innovation Clusters: People, Locations, Companies

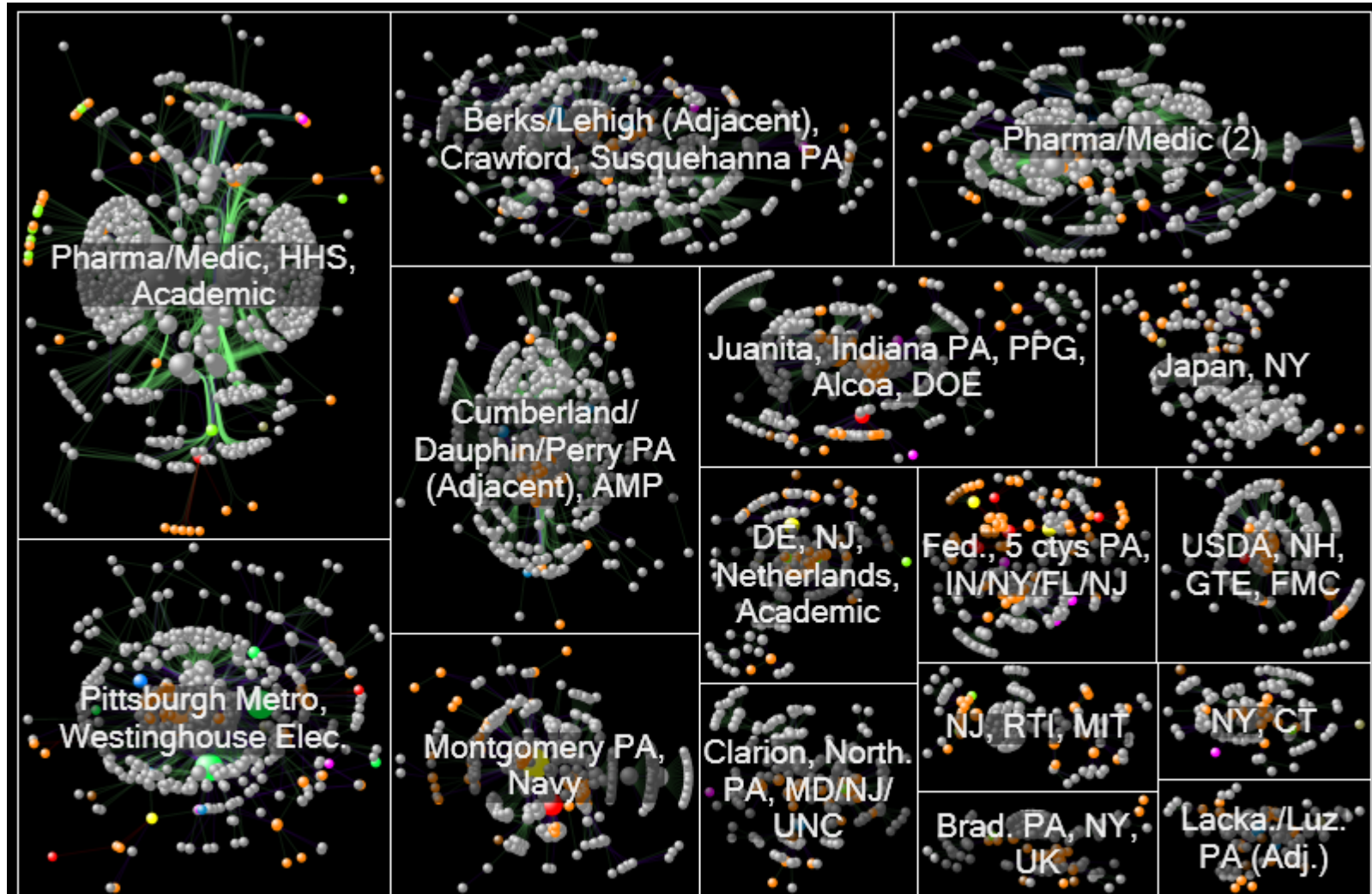


11,000 nodes
26,000 links

Innovation Clusters: People, Locations, Companies



Innovation Clusters: People, Locations, Companies



Edge Properties

0 135

Value

Opacity

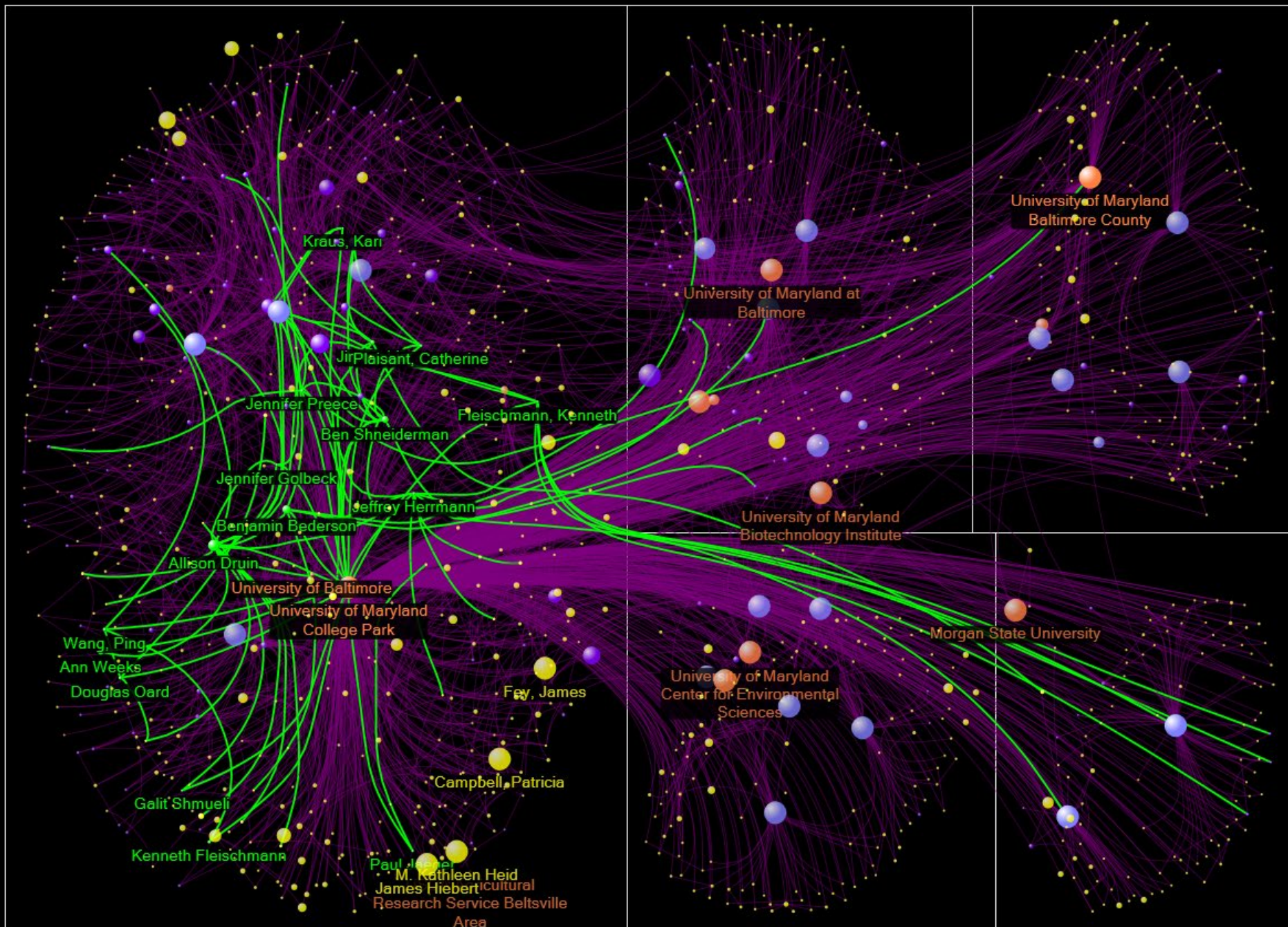
Vertex Properties

1 312

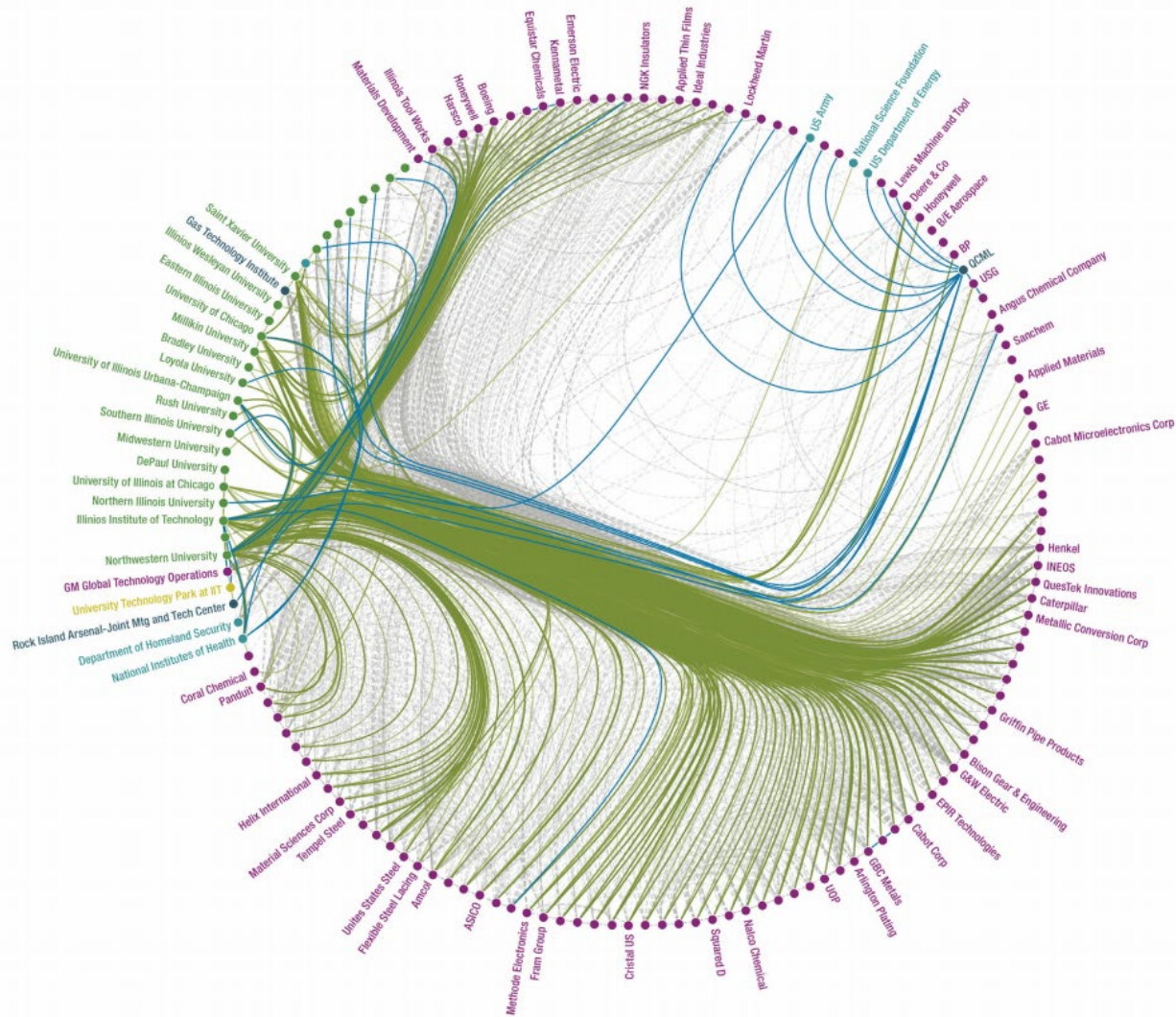
Degree

Size



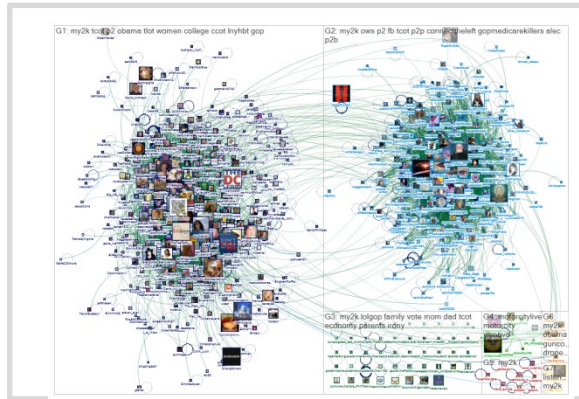


Illinois Economic Development: Scott Dempwolf

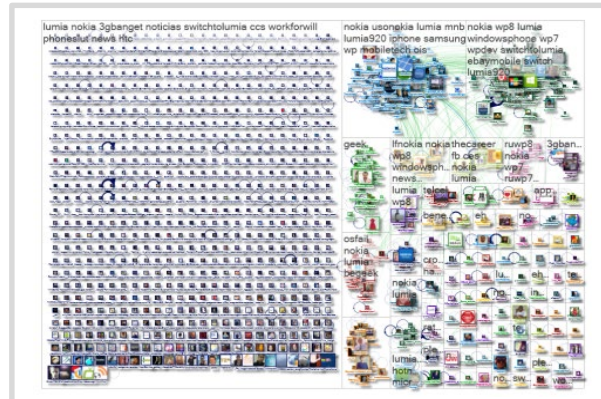


6 Twitter Network Structures

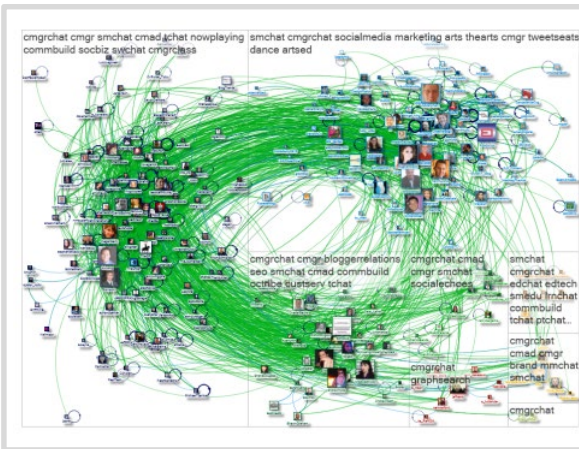
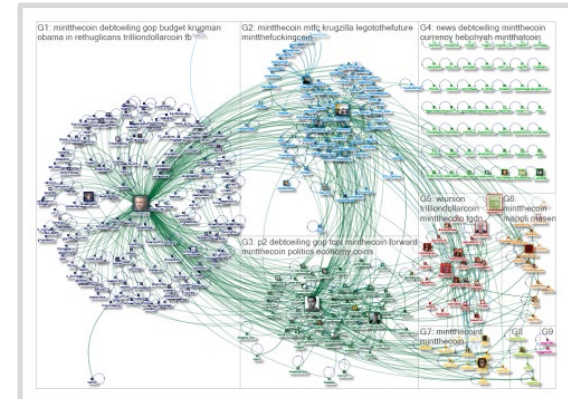
[Divided]
Polarized Crowds



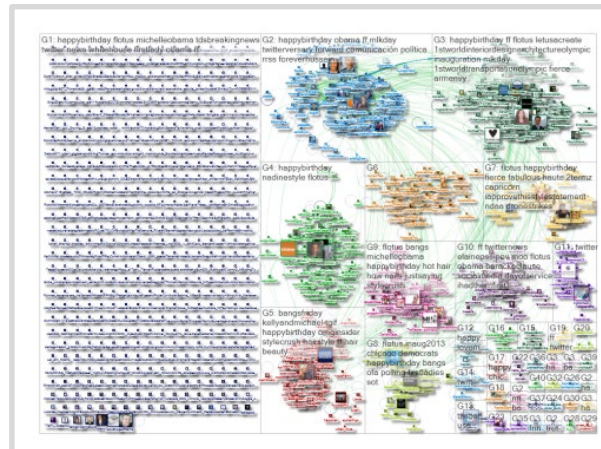
[Fragmented]
Brand Clusters



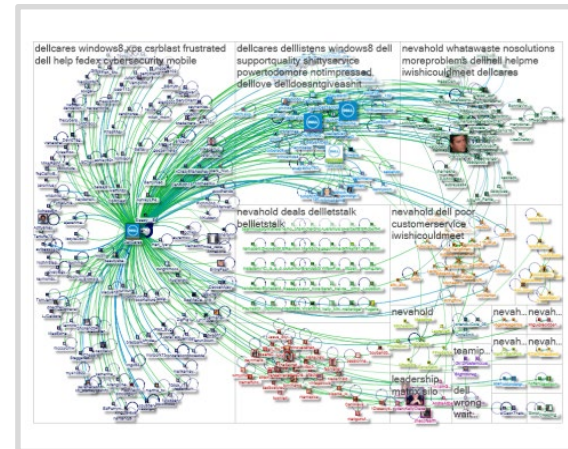
[In-Hub & Spoke]
Broadcast Network



Tight Crowd
[Unified]



Community Clusters
[Clustered]



Support Network
[Out-Hub & Spoke]



Social media network connections among Twitter users mentioning "Polio"

G1: polio paralymptics whosearorç nigeriaparalympic paralymptians haiti usa discus paralympt

G2: polio rotary ppnews afghanistan pakistan pathogenposse chaman balochistan rotaryinternacional mnch

G4: polio asiateggara rumordanfakta who salk pakistan paralymptics web mobile

G5: polio pakistan vaccination afghanistan sindh paralymptics chaman poliofreepakis...
G6: polio paralympt... haiti pakistan vaccinated endofpolio

G7: polio ppnewsindia
G8: polio 10ths... deprive
G9: polio whose...
G10: upa
G11: polio pol...
G12: polio pol...
G13: polio pol...
G14: polio pol...
G15: polio pol...
G16: polio pol...
G17: polio pol...
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G98: polio pol...
G99: polio pol...
G100: polio pol...

G3: polio pakistan karachi vaccination peshawar asifa children balochistan afghanistan pakistani

Analyzing Social Media Networks with NodeXL

I. Getting Started with Analyzing Social Media Networks

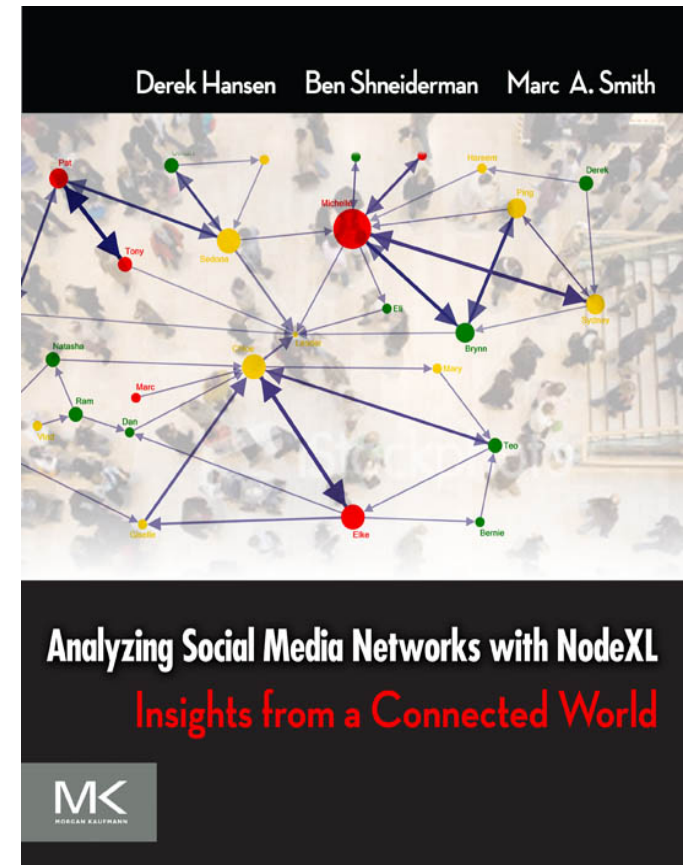
1. Introduction to Social Media and Social Networks
2. Social media: New Technologies of Collaboration
3. Social Network Analysis

II. NodeXL Tutorial: Learning by Doing

4. Layout, Visual Design & Labeling
5. Calculating & Visualizing Network Metrics
6. Preparing Data & Filtering
7. Clustering & Grouping

III Social Media Network Analysis Case Studies

8. Email
9. Threaded Networks
10. Twitter
11. Facebook
12. WWW
13. Flickr
14. YouTube
15. Wiki Networks



8 Golden Rules of Data Science

Preparation

- Choose actionable problems & compelling theories
- Open your mind: domain experts & statisticians

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Exploration

- If you don't have questions, you're not ready.
- Clean, clean, clean,...your data (*gently on the screen*)
- Know thy data: ranges, patterns, clusters, gaps, outliers, missing values, uncertainty

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- Know thy data: ranges, patterns, clusters, gaps, outliers, missing values, uncertainty

Decision

- Evaluate your efficacy, refine your theory
- Take responsibility, be resilient in the face of failure
- World is complex, proceed with humility





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Welcome to IEEE VIS 2019 in Vancouver!

VIS 2019 will be the year's premier forum for advances in theory, methods, and applications of visualization and visual analytics. The conference will convene an international community of researchers and practitioners from universities, government, and industry to exchange recent findings on the design and use of visualization tools.

We invite you to share your research, insights, and enthusiasm at IEEE Visual Analytics Science and Technology (VAST), IEEE Information Visualization (InfoVis), and IEEE Scientific Visualization (SciVis). The 2019 program will also feature a diverse range of symposia and co-located events, including Visualization in Practice, Visualization in Data Science, the VIS Arts Program, and data analysis Challenge competitions, as well as a new Application Spotlights track.

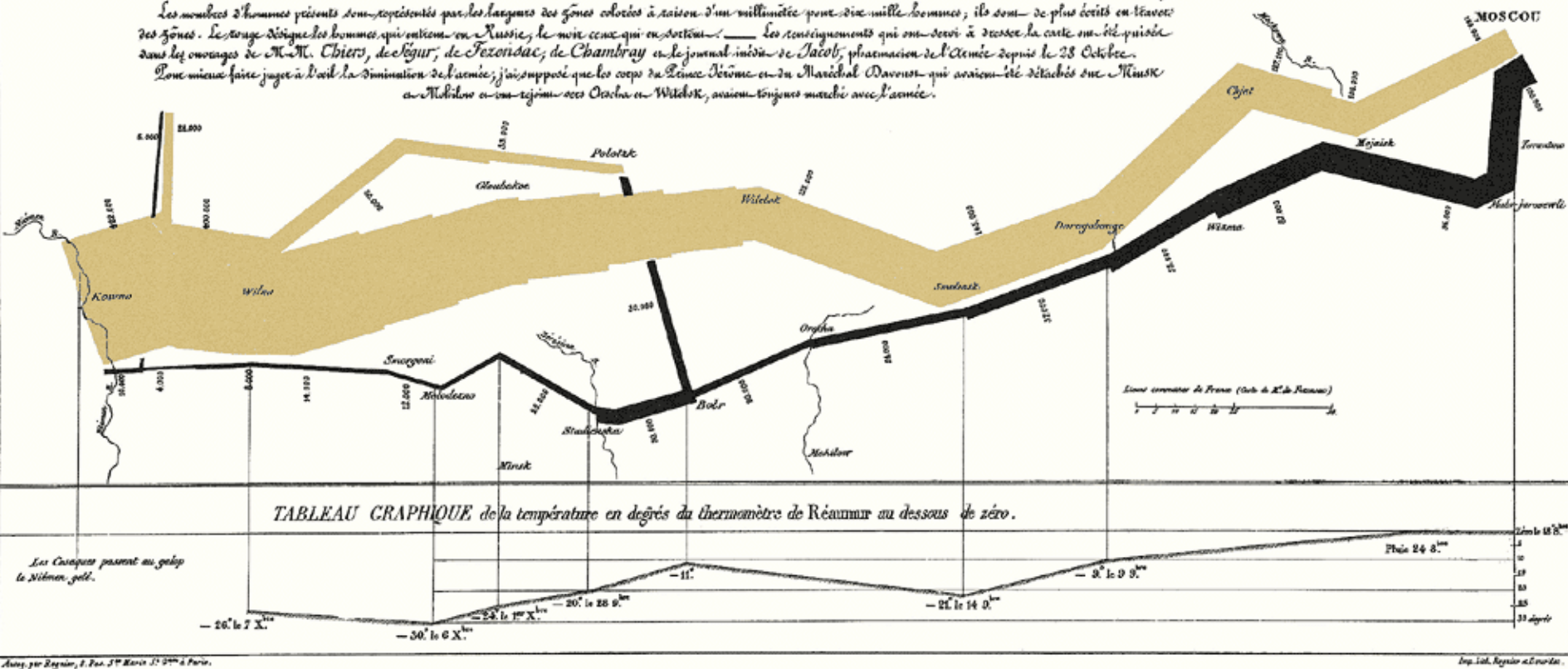
**The purpose of
visualization
is insight,
not pictures**

Minard's Napoleon's 1812 March

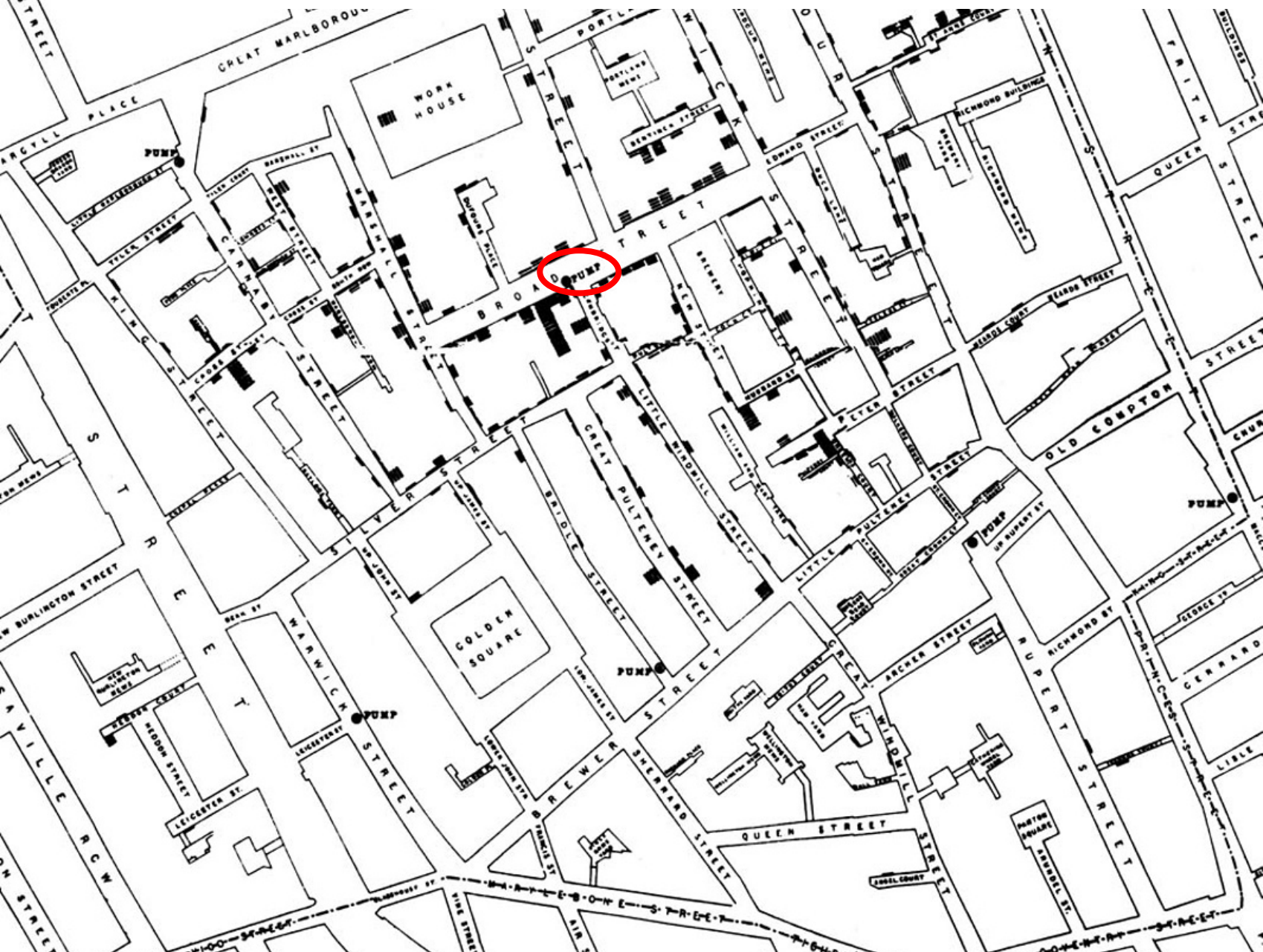
Carte Figurative des pertes successives en hommes de l'Armée Française dans la campagne de Russie 1812-1813.

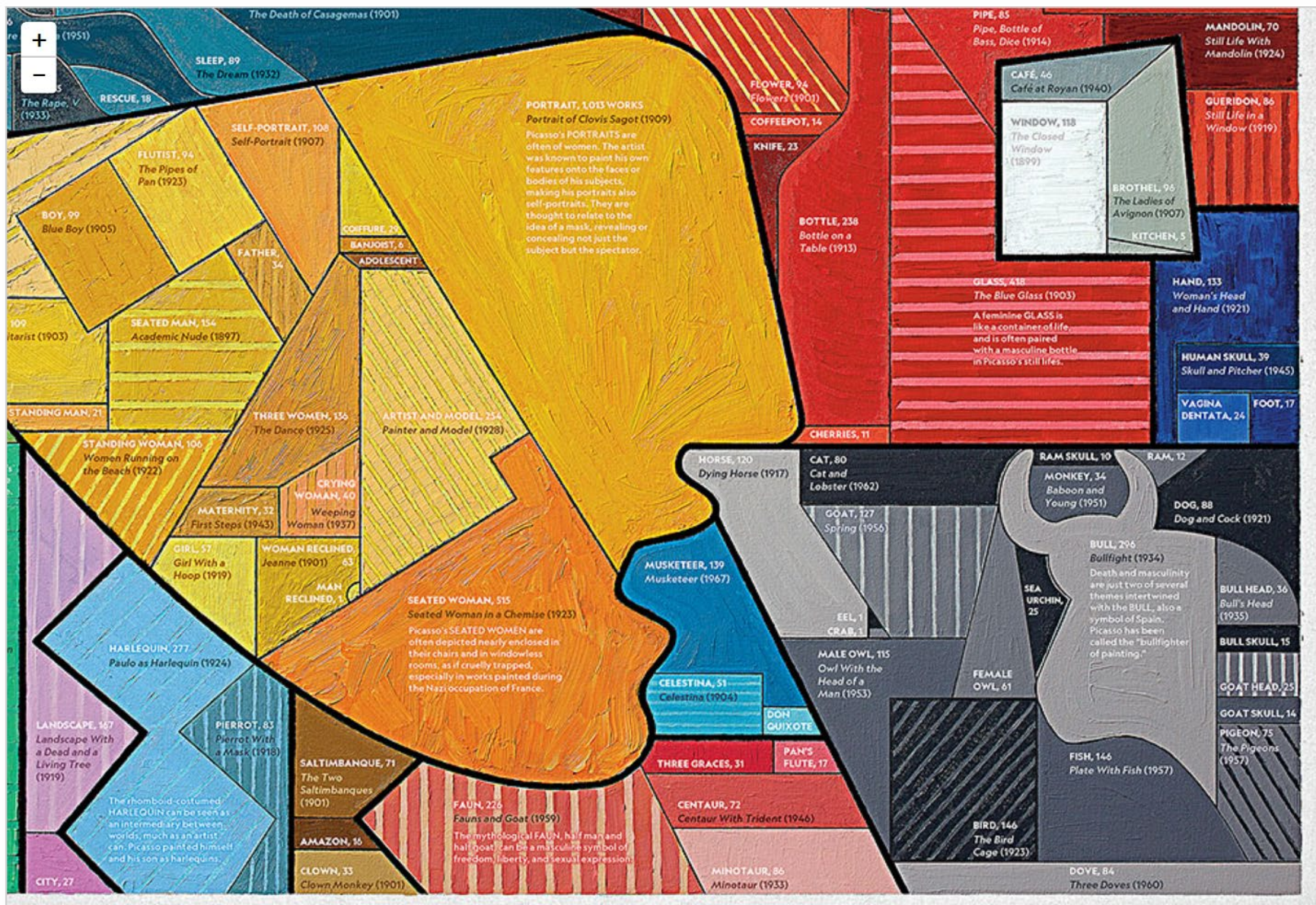
Dessinée par M. Minard, Inspecteur Général des Ponts et Chaussées en retraite. Paris, le 20 Novembre 1869

Les nombres d'hommes présents sont représentés par les largeurs des zones colorées à raison d'un millimètre pour dix mille hommes; ils sont de plus écrits en lettres des zones. Le rouge désigne les hommes qui ont été en Russie, le noir ceux qui en sont sortis. Les renseignements qui ont servi à dresser la carte ont été puisés dans les ouvrages de M. M. Thiers, de Séguier, de Fozzardac, de Chambray et le journal inédit de Jacob, pharmacien de l'Armée depuis le 28 Octobre. Pour mieux faire juger à l'œil la diminution de l'armée, j'ai supposé que les corps de la Grande Armée en du Maréchal Davout qui avaient été détachés sur Minsk et Mielow et qui rejoignent Otscha et Wilna, avaient toujours marché avec l'armée.



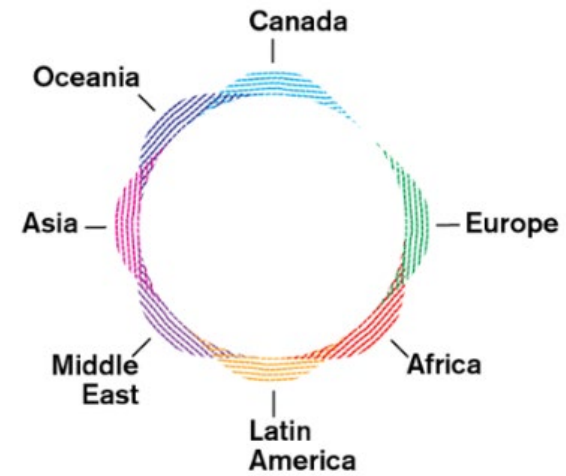
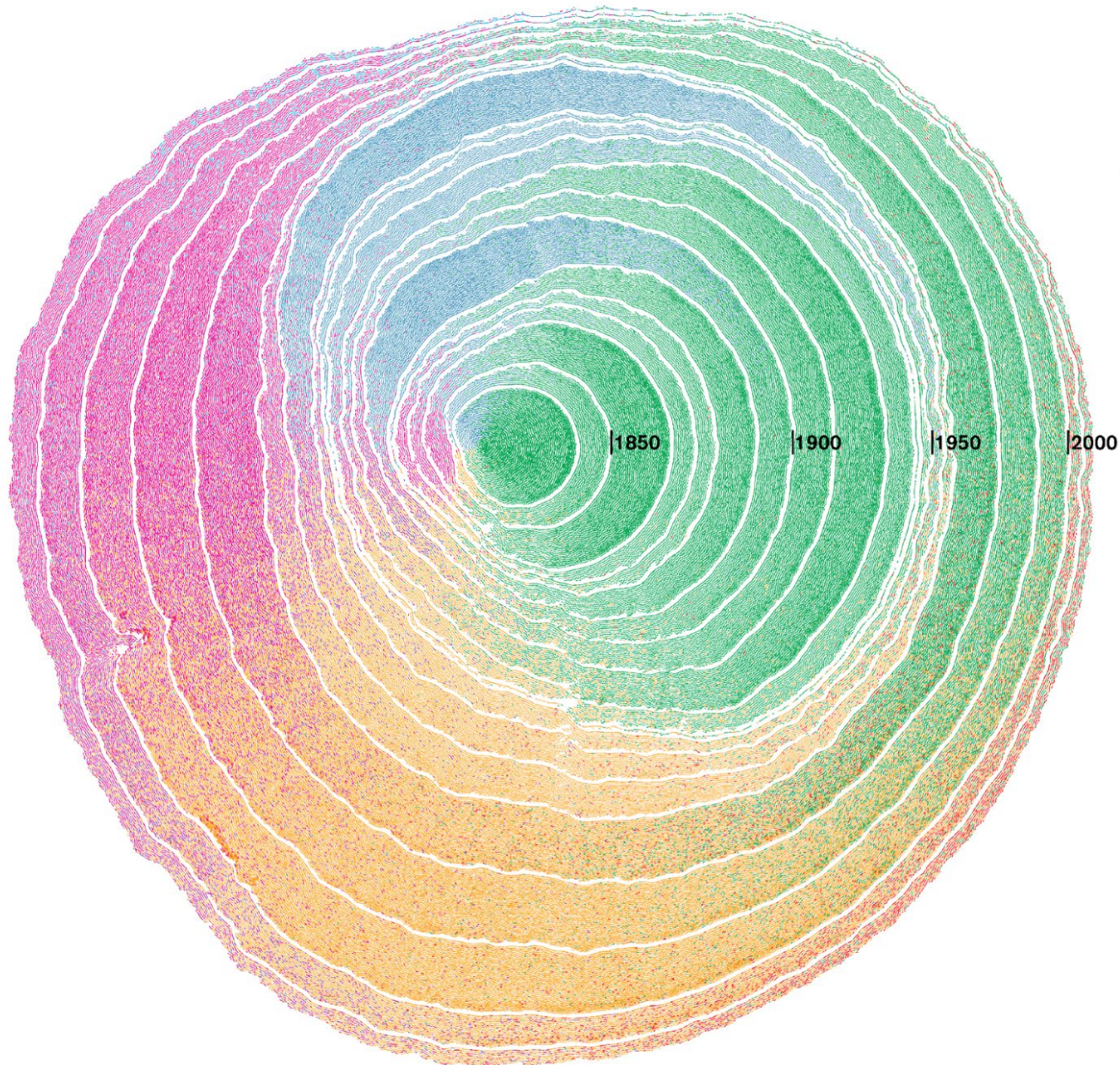
John Snow's London Cholera May 1854





<https://www.nationalgeographic.com/magazine/2018/05/genius-picasso-art-categories-infographic/>

A tree for U.S. immigration



<https://web.northeastern.edu/naturalizing-immigration-dataviz/>

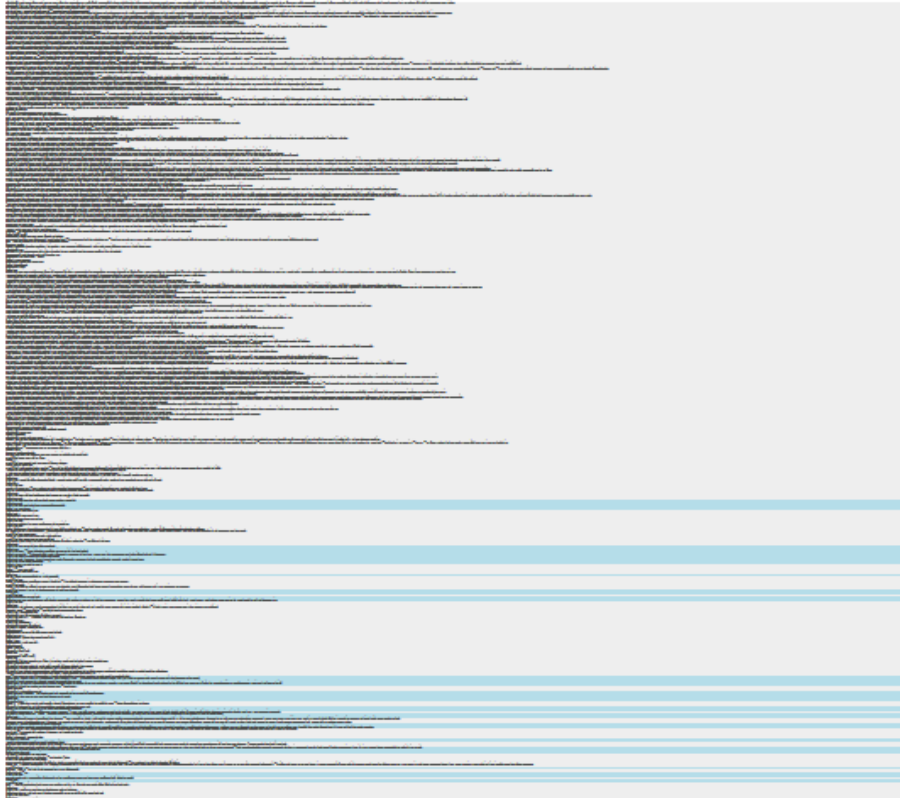


Ford-Kavanaugh Testimony

■ Answers question

■ Does not answer question

Ford

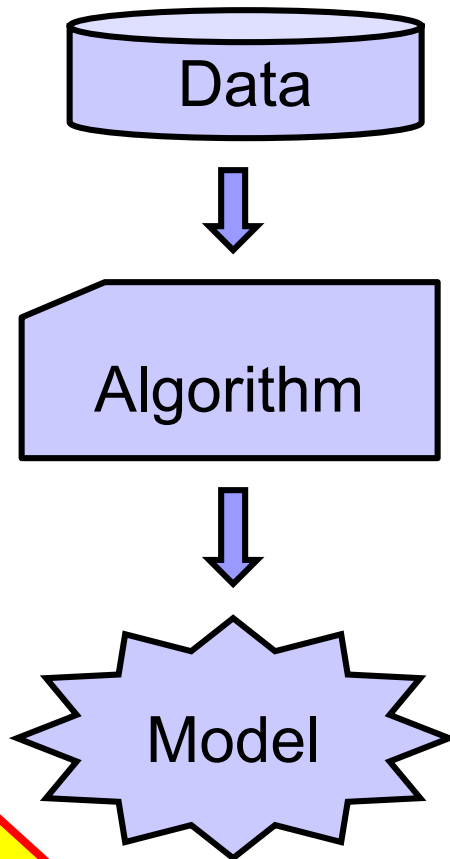


Kavanaugh

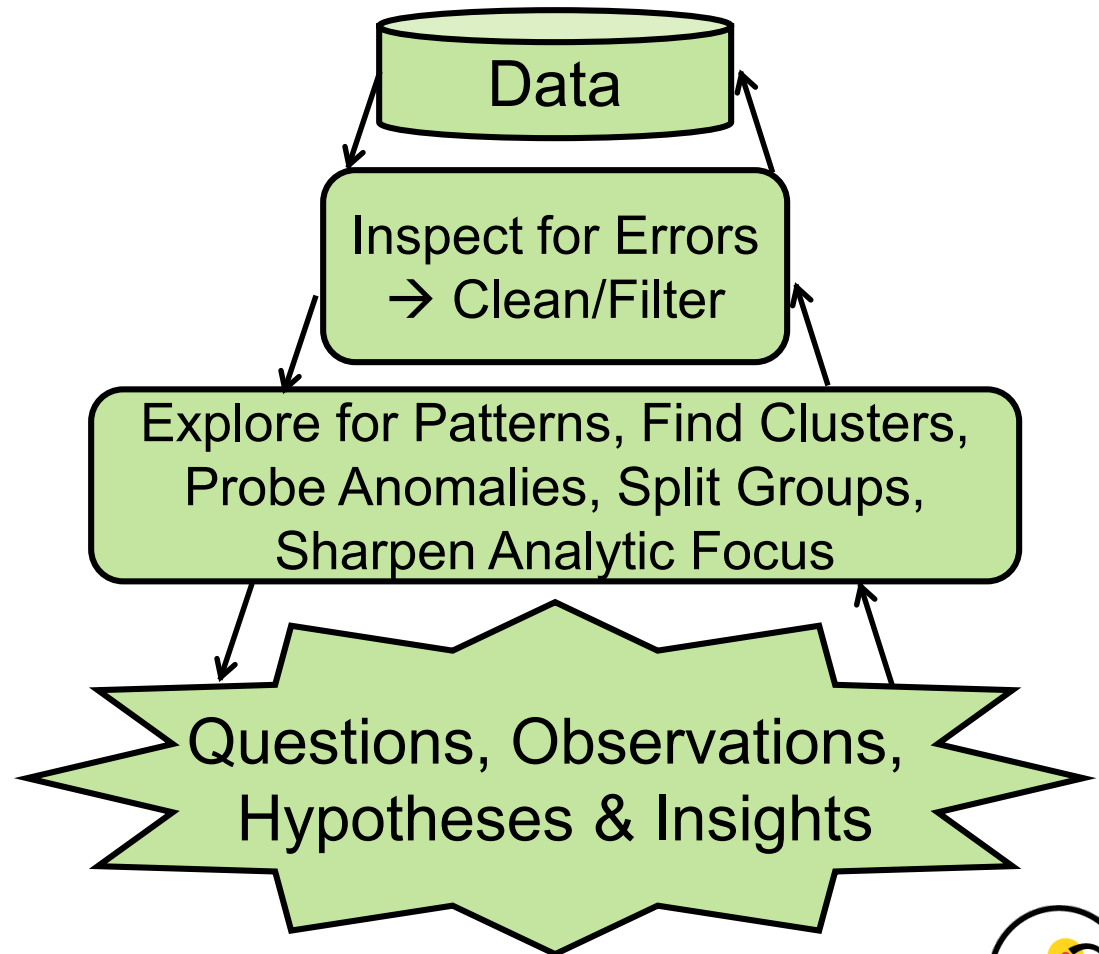


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Statistical Methods
Machine Learning



Visual Analytics



Comic Book
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- See Chapter 16 on Info Visualization
Shneiderman, B. et al., *Designing the User Interface: Strategies for Effective Human-Computer Interaction: Sixth Edition* (2016) <http://bit.ly/1T5UGn0>
- Card, S., Mackinlay, J., and Shneiderman, B. (1999)
Readings in Information Visualization: Using Vision to Think
- Munzner, T. (2014), *Visualization Analysis & Design*
- Wikipedia
 - https://en.wikipedia.org/wiki/Visual_analytics
 - https://en.wikipedia.org/wiki/Information_visualization

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- **Treemaps**
 - **Visual Action:** www.visualaction.com
 - **Apps:** finviz.com datausa.io
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