

Information Visualization Introduction

Sungahn Ko

HAiV

0

Disclaimer

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- The slides cannot be distributed, posted or used outside of this class
- Slides in this course courtesy of
 - Dr. Ross Maciejewski (ASU)
 - Dr. Niklas Elmquist (UMD)
 - Dr. David Ebert (OU)
 - Dr. Yun Jang (Sejong Univ.)

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About Topics

Haiv

- <https://sites.google.com/view/haiv/>

- This course will cover the topics in

- (Mainly) Information visualization

- IEEE VIS

- <https://ieevis.org/year/2024/welcome>

- UIST, HCI, if necessary

- ACM CHI, UIST

- <https://chi2024.acm.org/>

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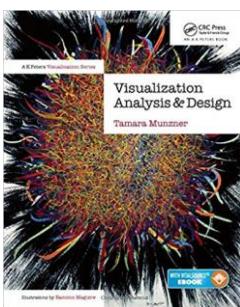
Textbook and reference materials

Haiv

- Prof. Tamara Munzner's book

- Exam and quiz questions from slides and videos

- <https://www.students.cs.ubc.ca/~cs-436v/22Jan/>



W.	Dats (Mo-Fr)	Async Video Lecture	Tue Class	Wed Tutorial Quizzes (due 6pm)	Thu Sync Class (11-12:20pm)	TA Office Hours	Fri Assign (due 6pm)
1	Jan 10-14	Intro & Abstractions	Logistics (livestream 11am)		Abstractions Released: P0, F1	no office hours first week	Refresher (No Quiz); Web c TutQuiz 1: Intro to D3 Foundations 1
2	Jan 17-21	Marks & Channels	no class	TutQuiz 2: Making a chart, reusable chart components	Marks & Channels P0		
3	Jan 24-28	Multivariate Tables	no class	TutQuiz 3: Enter/update, Joins	Multivariate Tables Released: P1, F2	P1	Programming 0
4	Jan 31-Feb 4	Interactive Views	no class	TutQuiz 4: Animated transitions, tooltips	Interactive Views Released: Project	P1	Foundations 2
5	Feb 7-11	Color	no class	TutQuiz 5: Multiple views, advanced interactivity	Color Released: F3	P2	Programming 1
6	Feb 14-18	Maps	optional stream Released: P2	TutQuiz 6: Geographic maps	Maps	P2	Foundations 3
7	Feb 21-25					P2	
8	Feb 28-Mar 4	Aggregation	no class	TutQuiz 7: Advanced concepts	Aggregation	Project Consult	Programming 2 Project Team Formation Milestone 1: Proposal
9	Mar 7-11	Networks & Trees	no class		Networks & Trees	Project Consult	
10	Mar 14-18	Rules of Thumb	no class		Midterm Review	Project Consult	
11	Mar 21-25	none	Midterm exam			Project Consult	
12	Mar 28-Apr 1	Advanced Topics: 1	no class Milestone 2: WIP			Project Consult	
13	Apr 4-8	Advanced Topics: 2	no class Milestone 3: Final Project		Advanced Topics Wrapup	Project Consult (project marking demo sessions)	

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Grading (Subject to Change)

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- **(Coding) Assignments but no grading**
 - UNIST TA is not available for grading
- **Offline Coding Exams: Similar/somewhat difficult compared to the assignments**
 - Mid-term 40%
 - Final Exam: 60%
- **No code pilot or LLMs are allowed during exams**
- **Online search (e.g., Googling) is okay**

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Coding Tutorial

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- **Coding Tutorial Videos**
 - About 3~4 times
- **Coding Q&A sessions via Zoom**
 - With a developer in our lab
- **Special Lecture Sessions**
 - By postdoc, senior Ph.d students
 - Date: TBA

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FAQ: Will I Need to Program?



- **Short answer: YES**

- This is basically a CSE course
- Will be easier if you are able to build software
 - Web-programming is easy (JavaScript etc)
 - Good opportunity to (force yourself to) learn

- **TA (UNIST)**

- Hyunsoo Kim hyunsukim@unist.ac.kr
- Jiun Min min1905@unist.ac.kr

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Slides



- The slides will be available in BB
- You are not allowed to distribute the slides
- Read materials and ask questions during class

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Academic Integrity

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- Violations of academic integrity include (but are not limited to) cheating, fabrication, tampering, plagiarism or facilitating such activities.
- I have a zero-tolerance policy. Any perceived cheating will make your grade F.
- Check guidelines
- If you have any question, ask me

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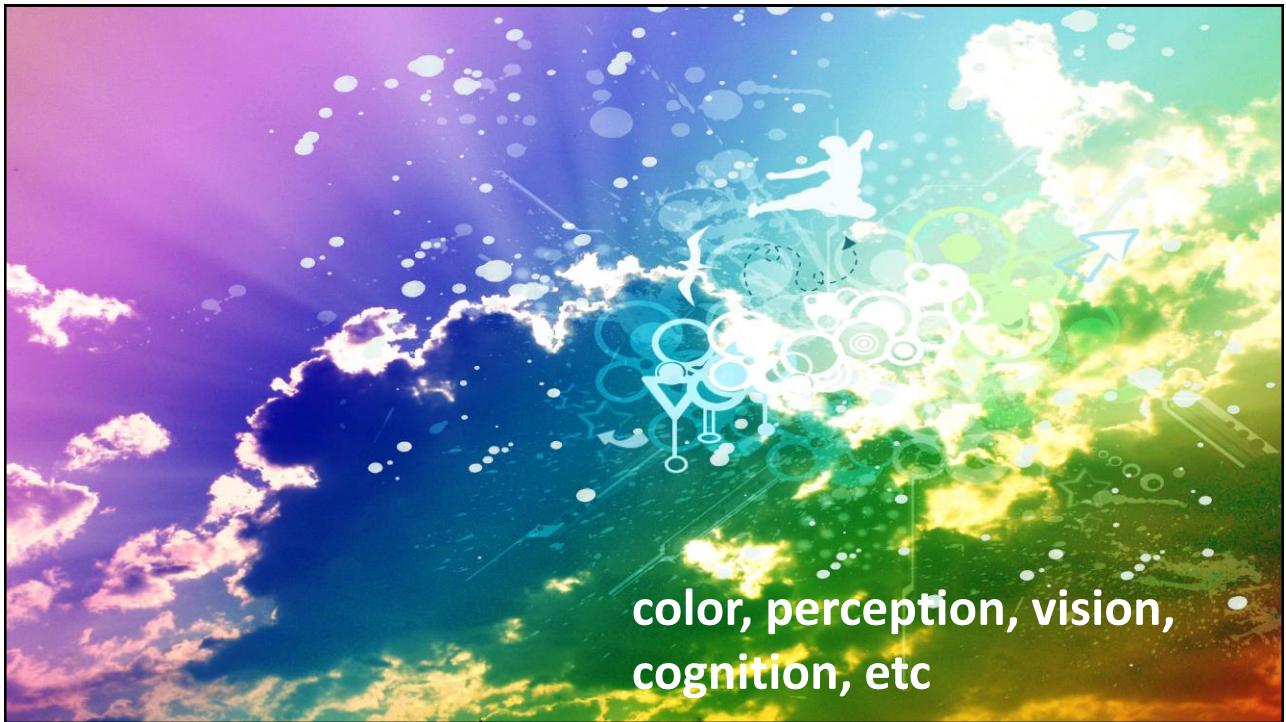
What will we cover in class?

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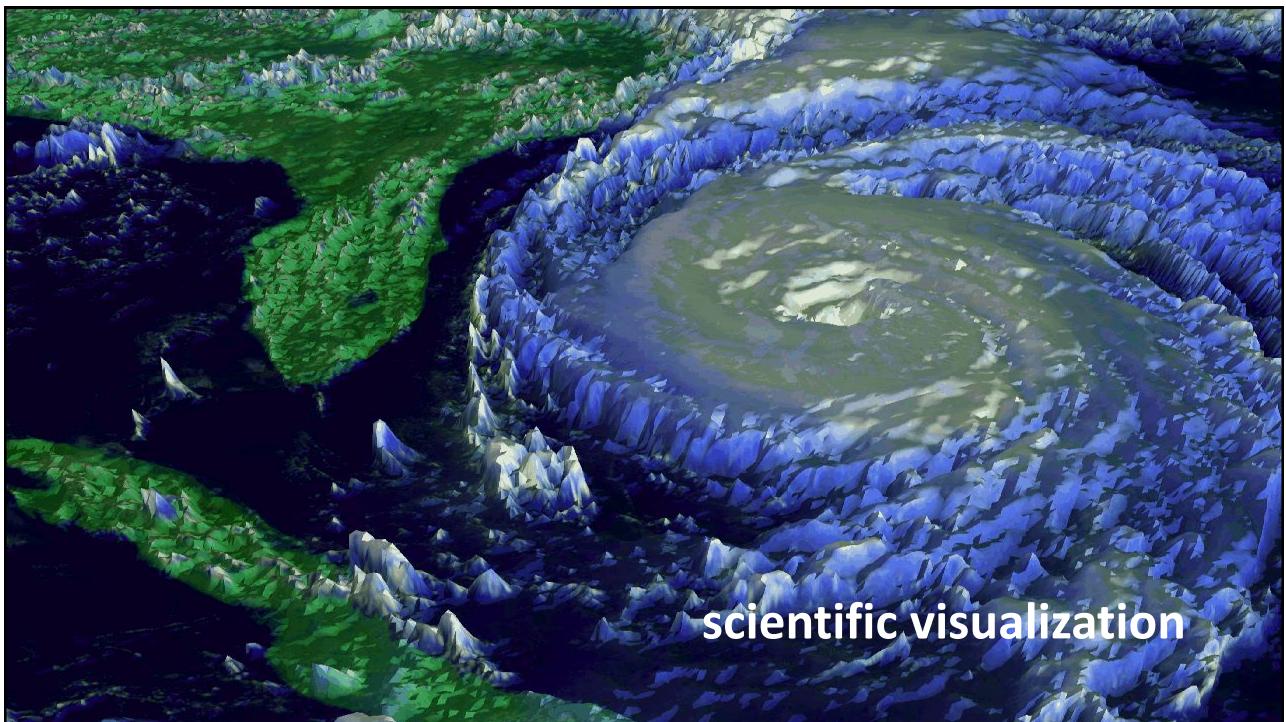
- Purposes and goals of visualization:
 - applications, challenges, sources of data
 - measurement, simulation, modeling
 - data dimensionality: 1D, 2D, 2.5D, 3D, ..., nD
 - time-dependent
 - data types: scalar, vector, nominal, multivariate
 - grid types: regular, rectilinear, curvilinear, unstructured, hybrid, point-based or scattered data

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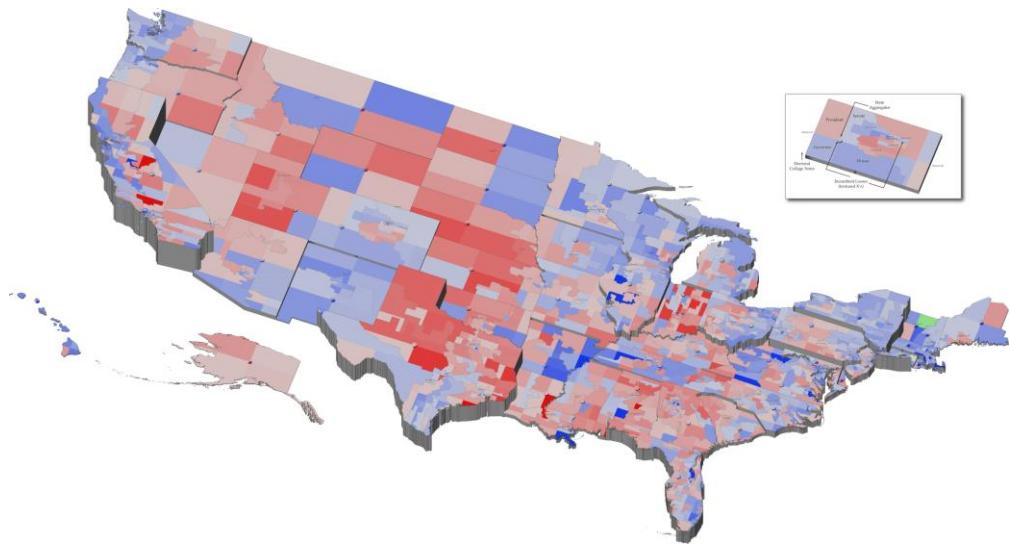
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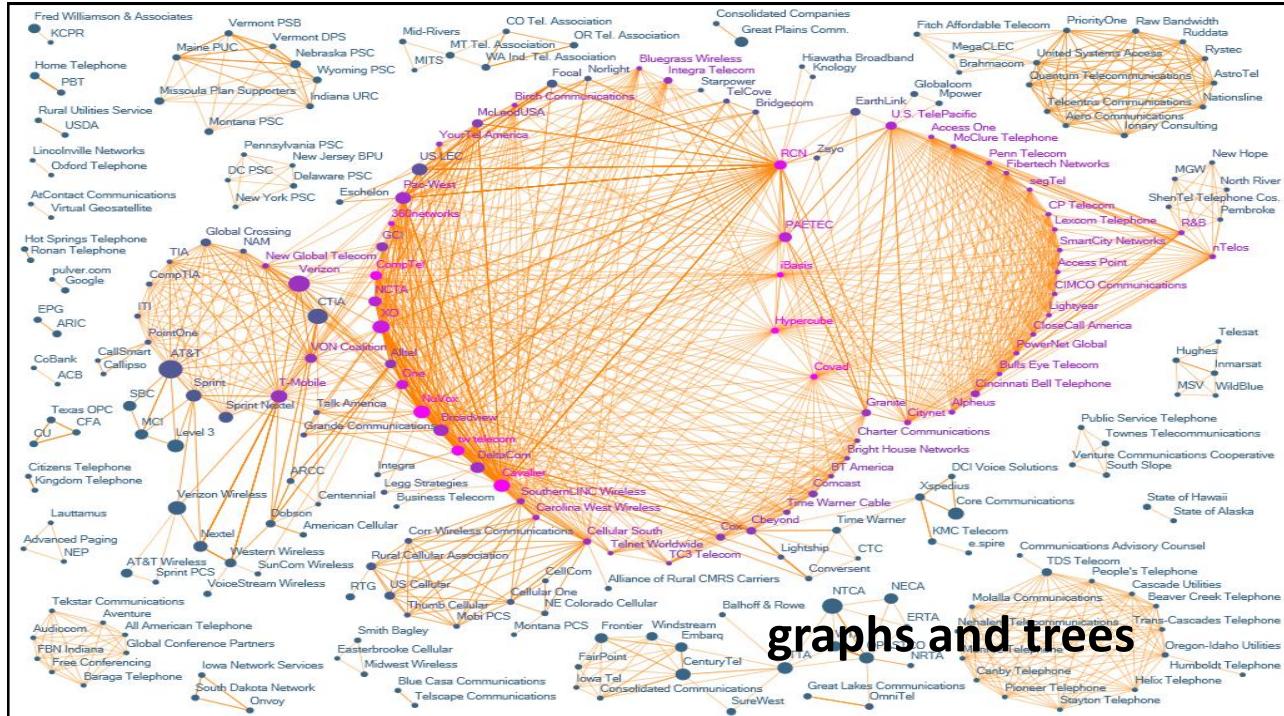


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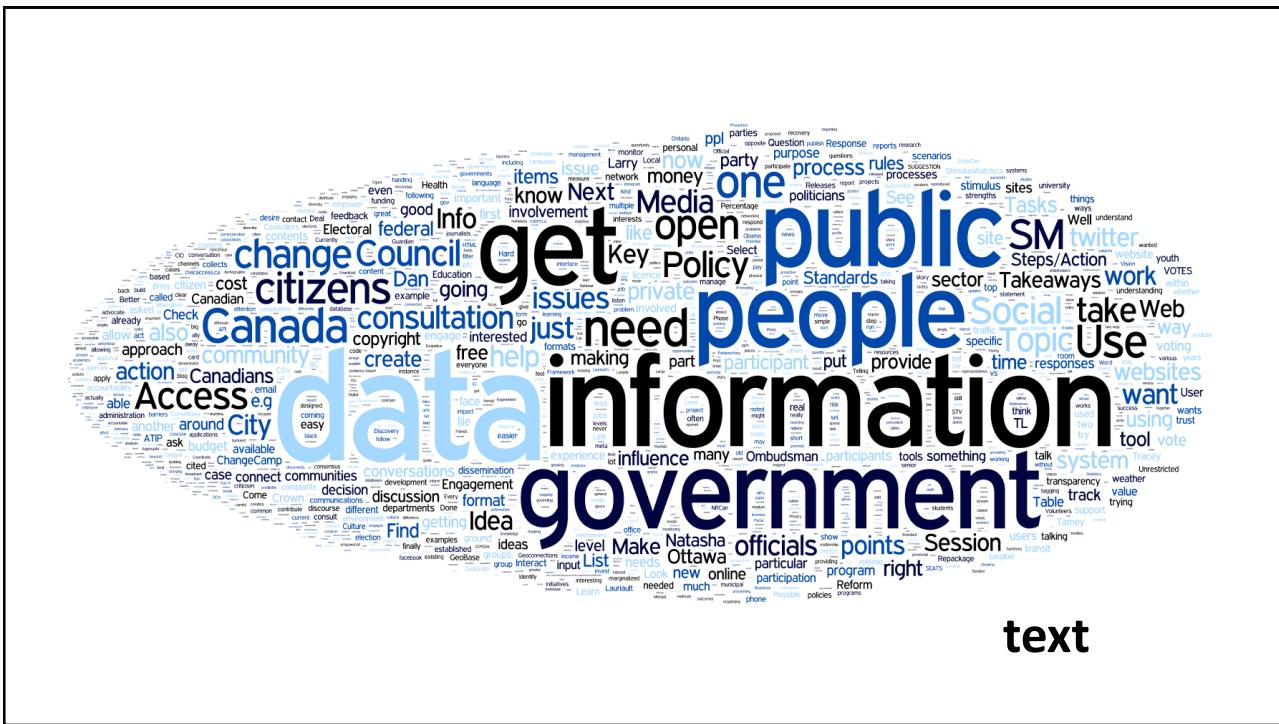


multidimensional visualization

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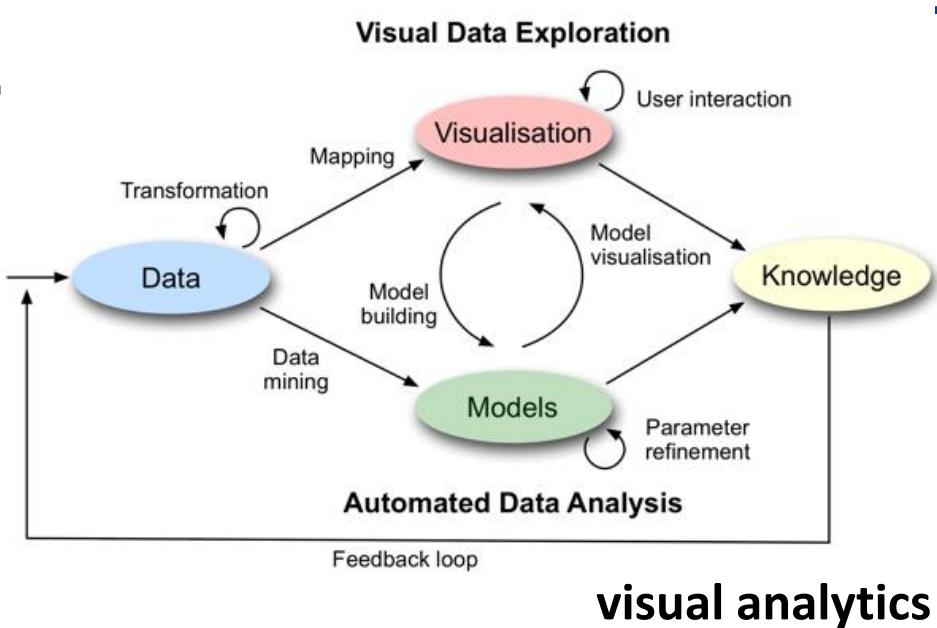
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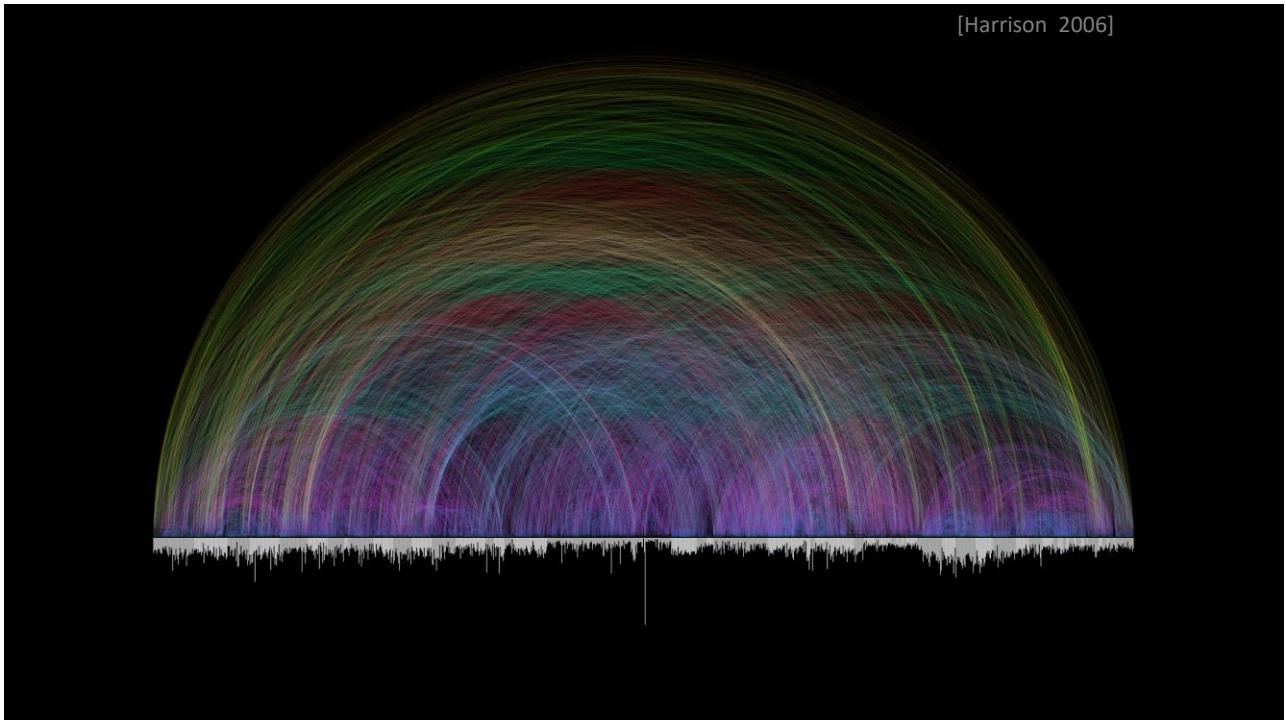
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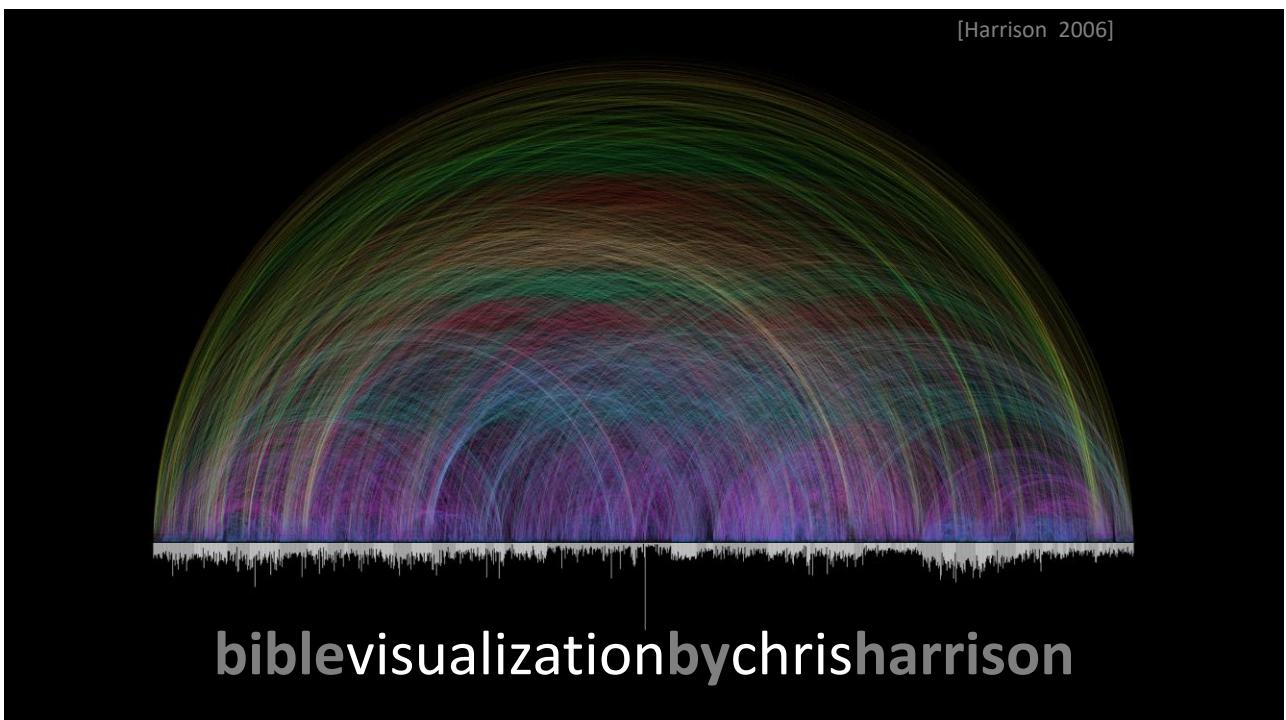
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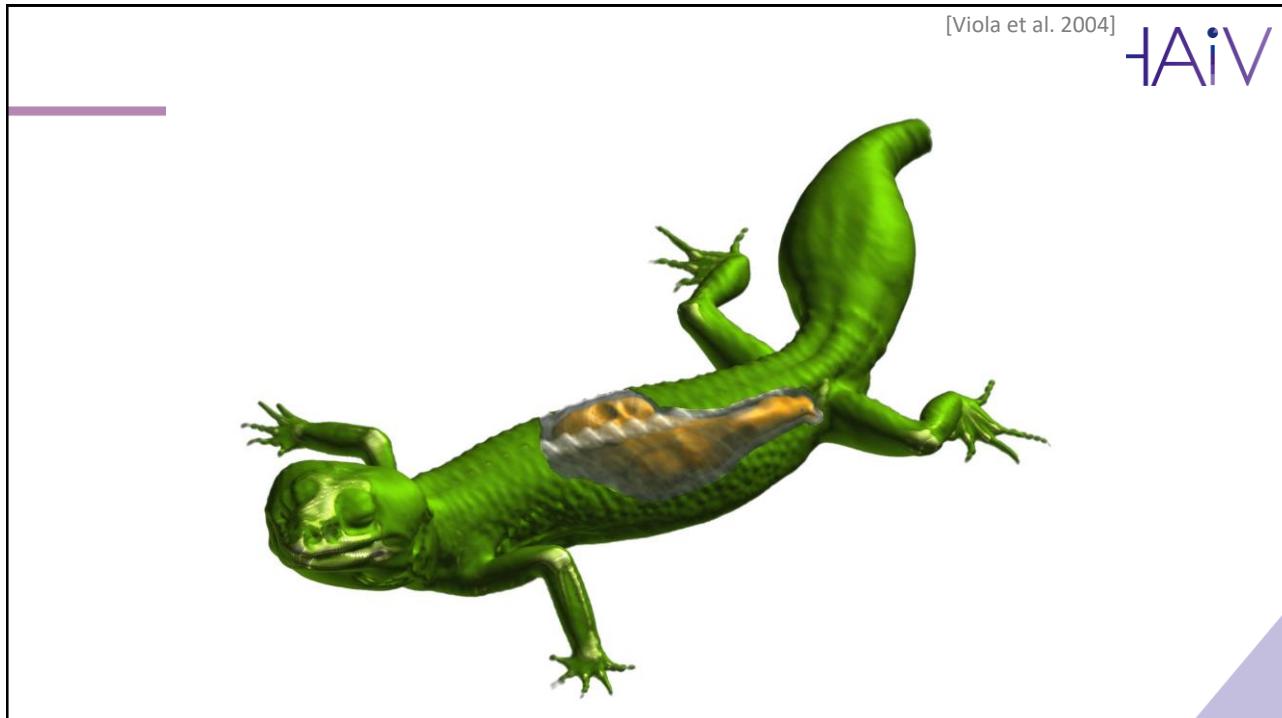
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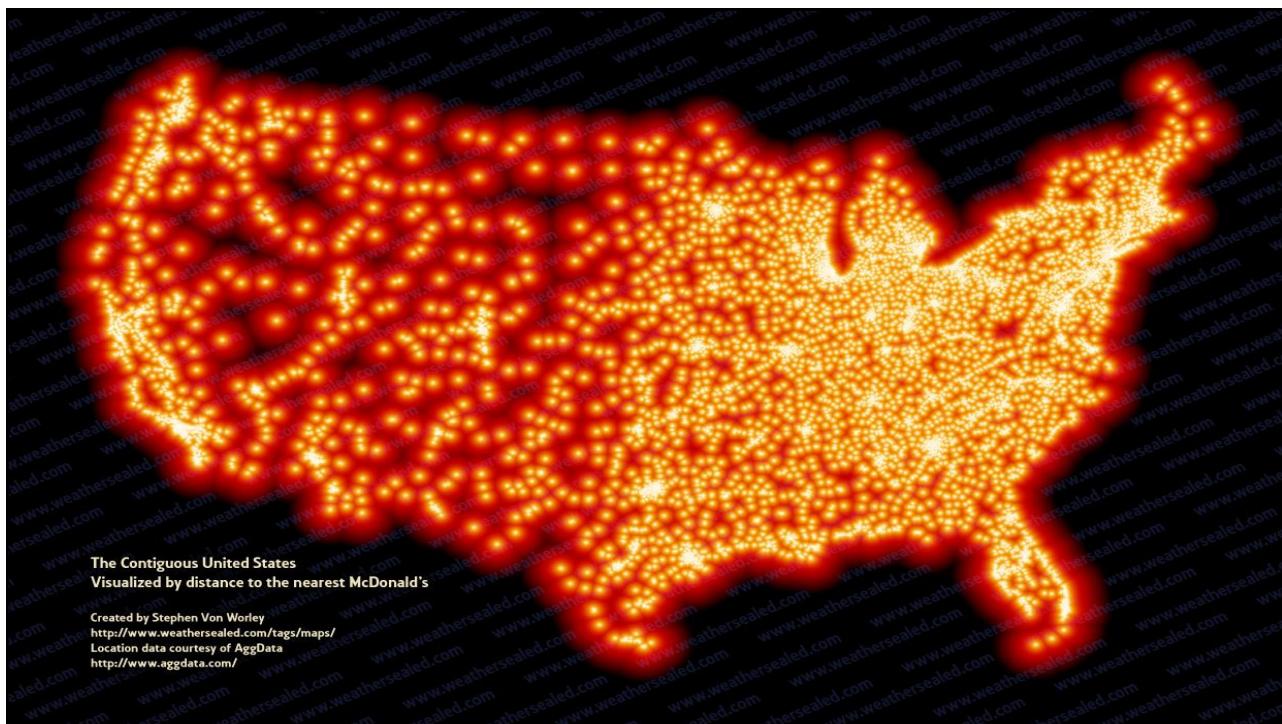
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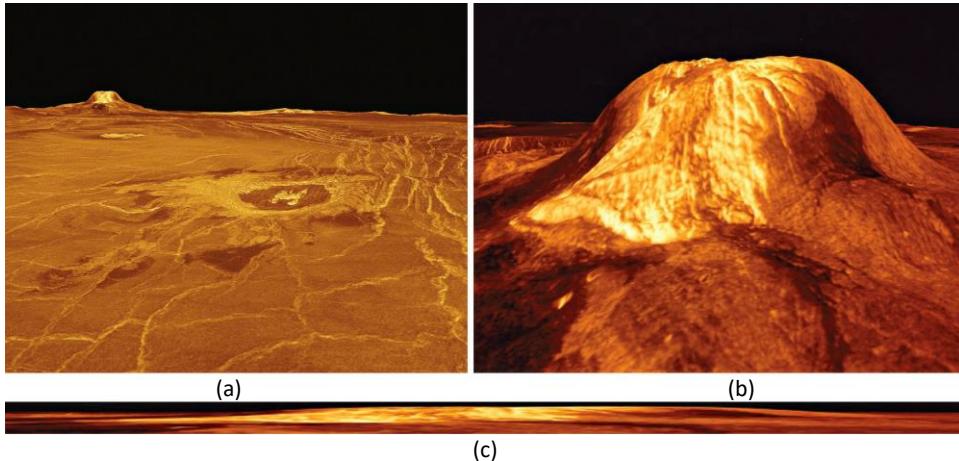
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[Hanson 2014]

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Eistla Regio region of the surface of Venus

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EDUCATING THE WORKFORCE OF FUTURE

Since 1973, the number of jobs that require at least some college has more than tripled, while those requiring a high school diploma or less have flattened.

A collaboration between GOOD and Hyperakt, in partnership with University of Phoenix.

BACHELOR'S AND ABOVE

ASSOCIATE'S OR TRADE SCHOOL

HIGH SCHOOL DIPLOMA OR LESS

GROWING AND DECLINING JOBS AND THEIR EARNING POTENTIAL

▲ Bachelor's or above □ Associate's or some college ▲ High School Diploma or less

HIGHEST GROWTH / LOWER WAGES

Job growth between 2000 and 2010 fastest

► Home health aids

► Personal and home care aides

► Medical assistants

► Veterinary technicians and technologists

► Dental assistants

► Medical assistants

► Physical therapist assistants

► Self-enrichment education teachers

► Compliance officers

LOWEST GROWTH / LOWEST WAGES

Job growth between 2000 and 2010 slowest

► Lathing and turning machine tool setters, operators, and tenders, metal and plastic

► Semiconductor processors

► Postal service mail carriers, processors, and machine operators

► Medical preysers

► Bookbinding, publishing, and allied workers

► Drilling and boring machine tool setters, operators, and tenders

► Lathes and turning machine tool setters, operators, and tenders

► Order clerks

► Service operators, oil and gas

► Desktop publishers

1973
91 MILLION
WORKERS

2007
154 MILLION
WORKERS

**PROJECTED
2018**
166 MILLION
WORKERS

60%

OF JOBS (AND GROWING) REQUIRE
AT LEAST AN ASSOCIATE'S DEGREE



BUT ONLY

40%

OF AMERICANS OBTAIN AN
A.A. OR B.A. BY THE AGE OF 27



PREPARING TO JOIN THE AMERICAN WORKFORCE

62% MORE STUDENTS ARE ENROLLED
IN POSTSECONDARY DEGREE-GRANTING
INSTITUTIONS NOW THAN 30 YEARS AGO

1980 12.1 MILLION **2009** 19.6 MILLION

BUT

"ON TIME" COMPLETION RATES ARE ALARMINGLY LOW



SOURCES

Bureau of Labor Statistics Occupational Employment Statistics and Division of Occupational Outlooks

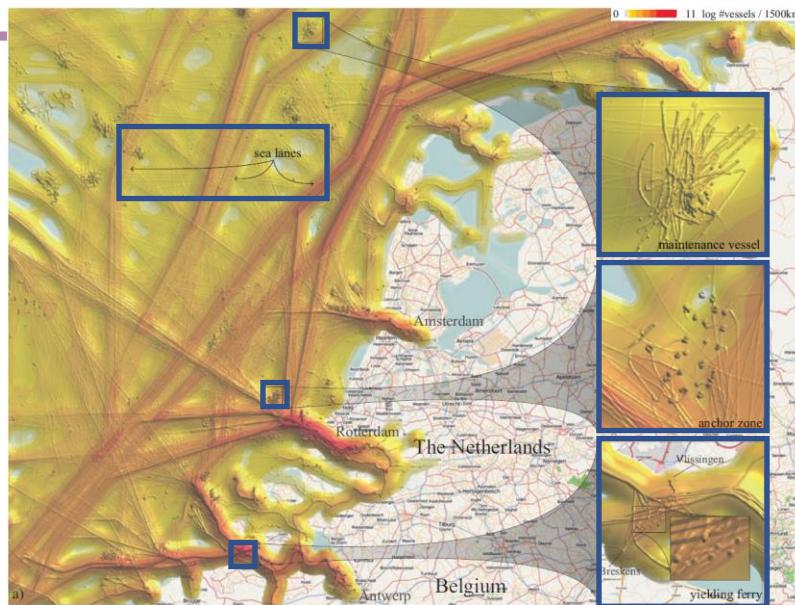
IETS National Center for Education Statistics, U.S. Department of Education Institute of Education Sciences, National Center for Education Statistics, Enrollment in educational institutions, by level and control of institution. Selected years, full-time through full-time.

Pathways to Prosperity Report, Harvard Graduate School of Education, February 2012

GOOD + University of Phoenix

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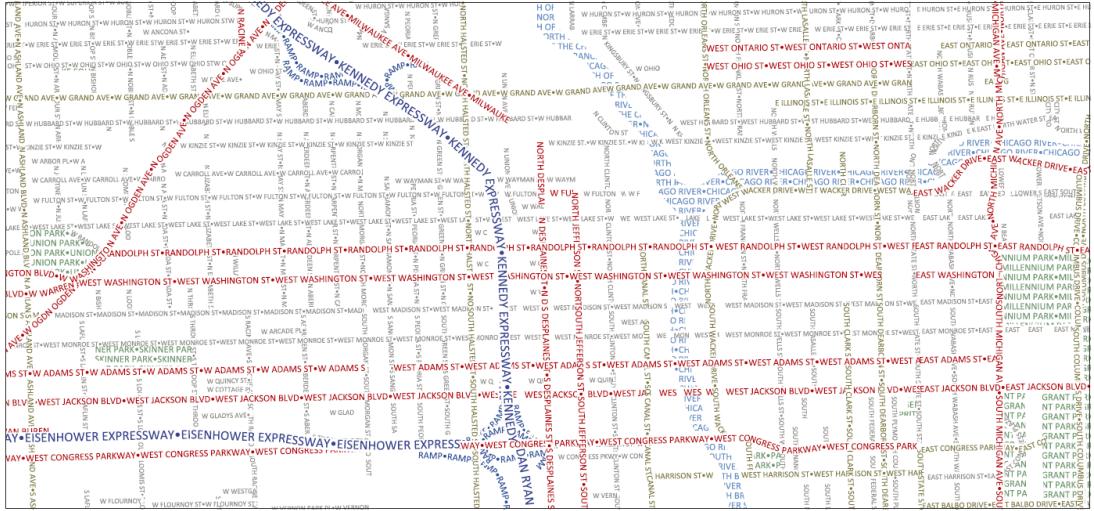
[Willems et al., 2009]



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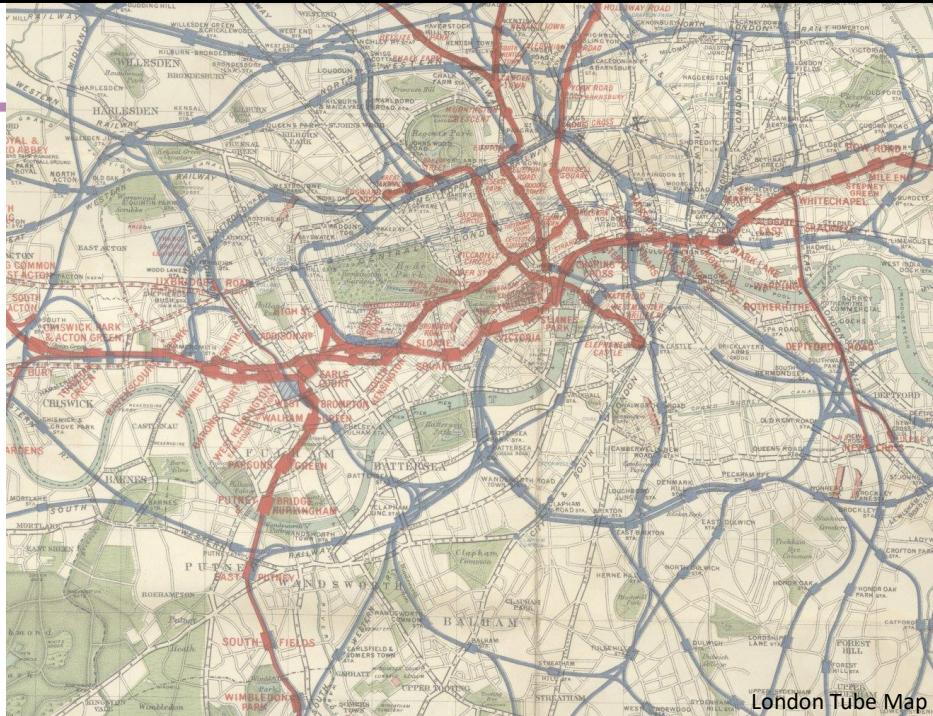
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[Afzal et al., 2012]

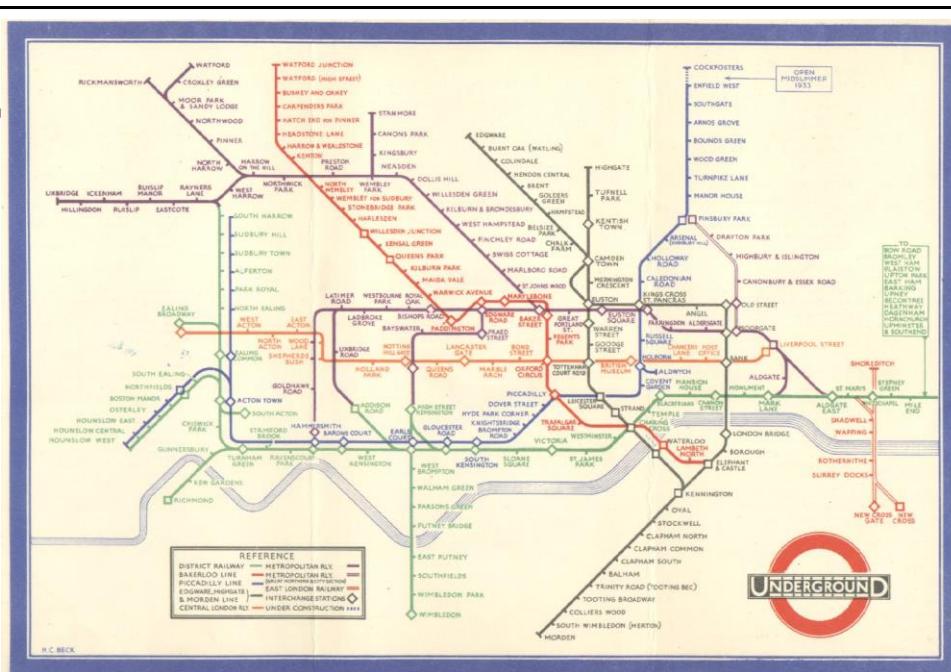


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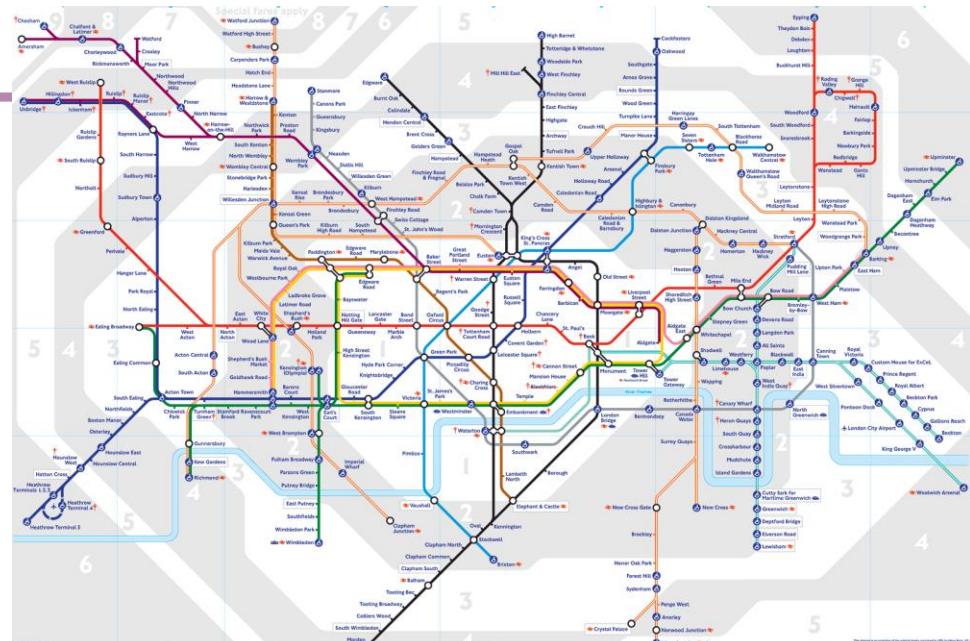
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[Harry Beck, 1933]

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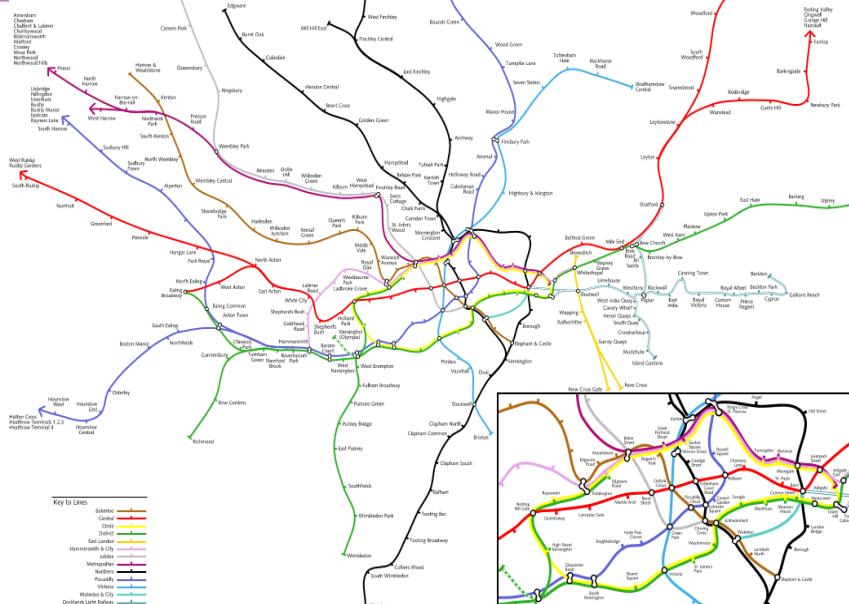


London Tube Map, 2010

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More information: <http://homepage.ntlworld.com/clivebillson/tube/tube.html>

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Why do we need?

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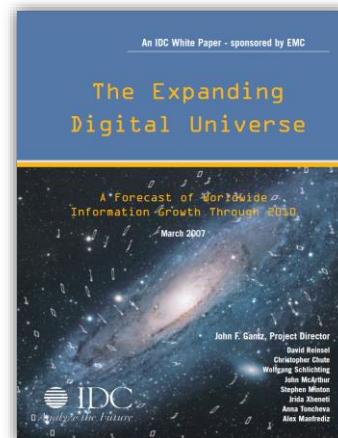
[Gantz et al. 2007]

The Digital Universe...

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- ~1 zettabyte of data in 2010 (988 EB)
 - 1,000,000,000,000,000,000,000 bytes (10^{21})
 - 95+% unstructured
 - Images, video, audio, etc
 - 1 billion digital capture devices in 2006
 - 25% original, 75% replicated

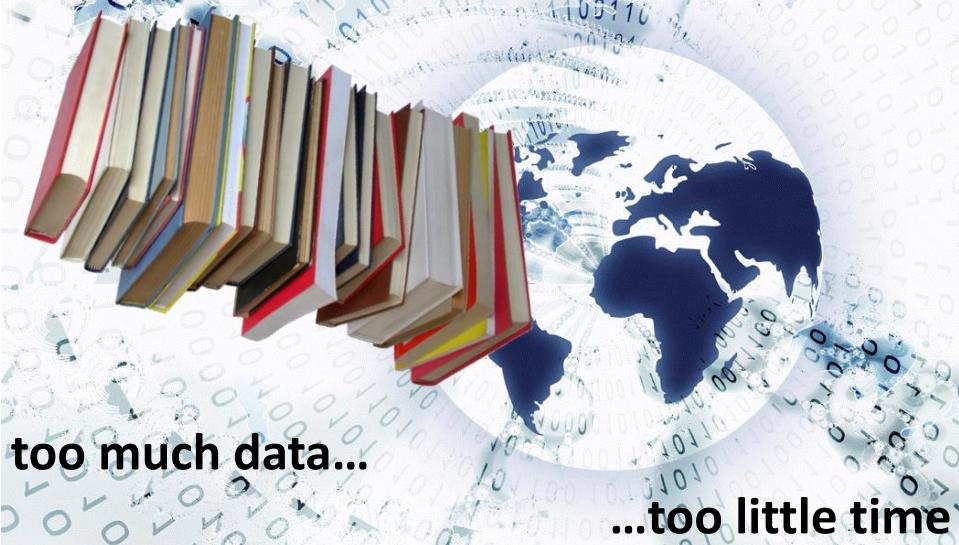
“...the digital universe will remain unstructured – meaning tools and techniques will be required to add structure [...] to improve **search, discovery, [and] management...**”



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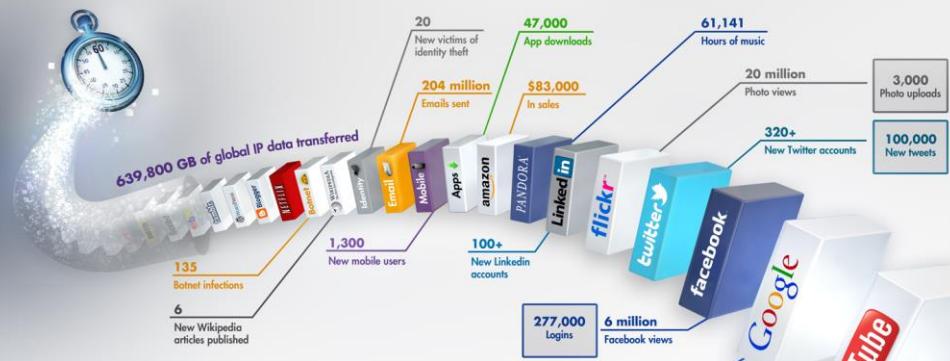
Same old story...

-AiV



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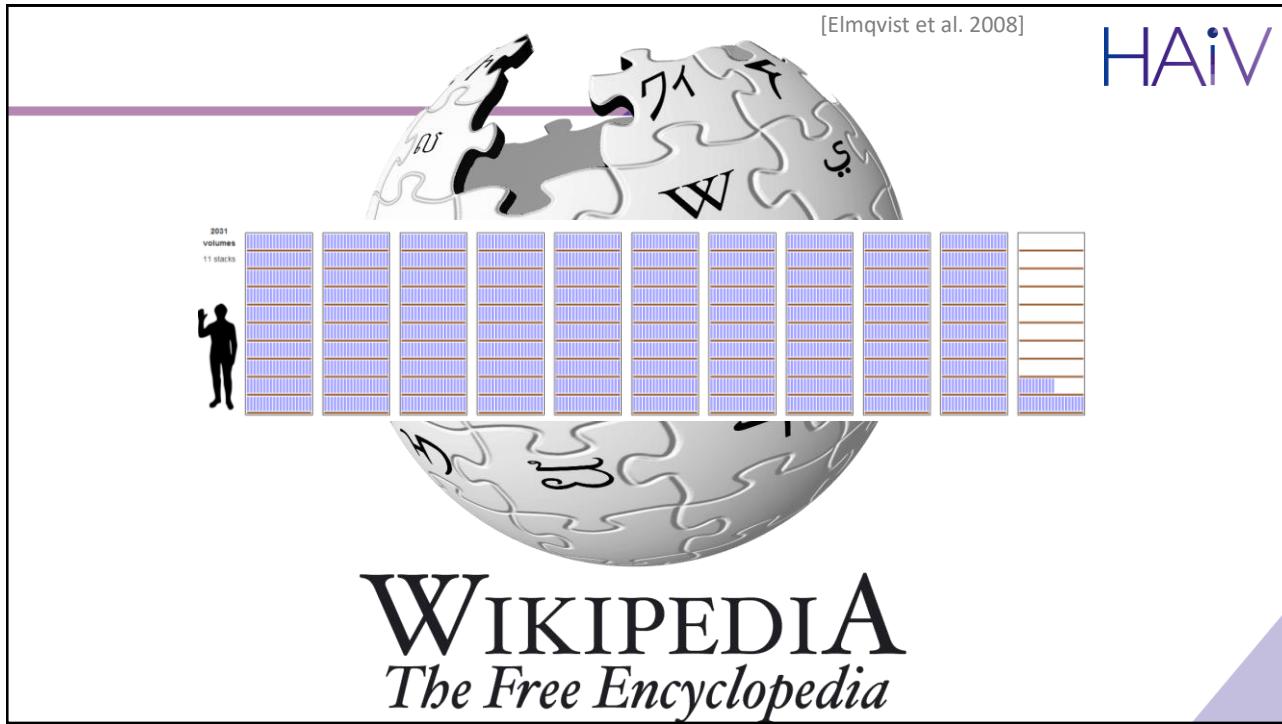
What Happens in an Internet Minute? |AiV



And Future Growth is Staggering



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The Ongoing Data Deluge

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- Since 2003, digital information has accounted for 90% of all information produced¹
- In 2009, drones from Iraq and Afghanistan recorded 24 years of video footage
- In 2010, the amount of information added annually to the digital universe was estimated to be nearly 1 ZB
- Wal-mart process > 1 million transactions per hour
- By 2013 Cisco estimates the annual internet traffic will be 667 EBs

1 – C. R. Johnson, R. Moorhead, T. Munzner, H. Pfister, P. Rheingans, and T. S. Yoo, Eds., *NII-NSF Visualization Research Challenges Report*, IEEE Press, ISBN 0-7695-2733-7, 2006

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The Ongoing Data Deluge

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- Consumers carry more than 1 billion Visa cards worldwide. More than 450 million of those cards are in the United States

- <http://www.creditcards.com/credit-card-news/credit-card-industry-facts-personal-debt-statistics-1276.php>

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Data Overload

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- **Opportunity:** Huge amounts of data available in digital form and ready for analysis!
- **Problem:** The amount of data is simply too huge for humans to analyze!
 - (Also, 95% of it is unstructured...)
 - But, how can we make sense of this data?
 - How can we harness this data in the decision making process?
 - How do we avoid being overwhelmed by all of this data?

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[Jeffrey Heer]

The Value of Visualization?



- Answering questions
- Confirm the expected
- Discover the unexpected
- Making decisions
- Expand memory
- Find patterns
- Tell a story
- Inspire others

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Answering Questions

The Value of Visualization

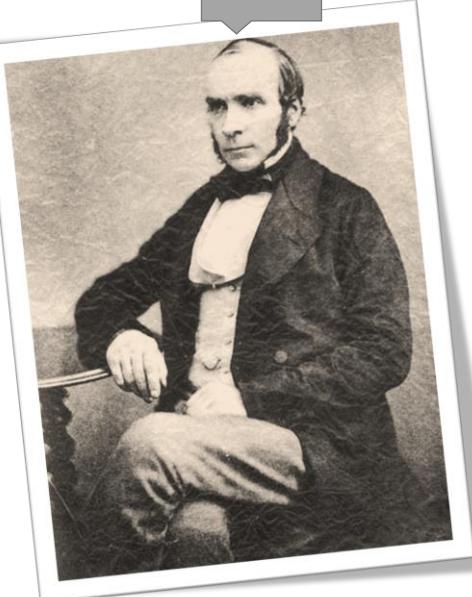


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John Snow and the London Cholera Outbreak

???

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Confirm the Expected

The Value of Visualization

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<https://www.youtube.com/watch?v=OlleAWikWQ>

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Expand Memory

The Value of Visualization

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External Cognition and Memory

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- External cognition is the use of the external world to achieve cognition
 - Scaife and Rogers (1996)
 - Explains the power of visualization
 - Example: post-it notes
- Three mechanisms
 - Offloading: supports memory
 - Re-representation: new form
 - Graphical constraining: utilize visual reasoning
- Don Norman: “It is things that make us smart.”

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Example: External Memory

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$$45 \times 93 = ???$$

$$\begin{array}{r} 45 \\ \times 93 \\ \hline 135 \\ + 405 \\ \hline \underline{4185} \end{array}$$

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Discover the Unexpected

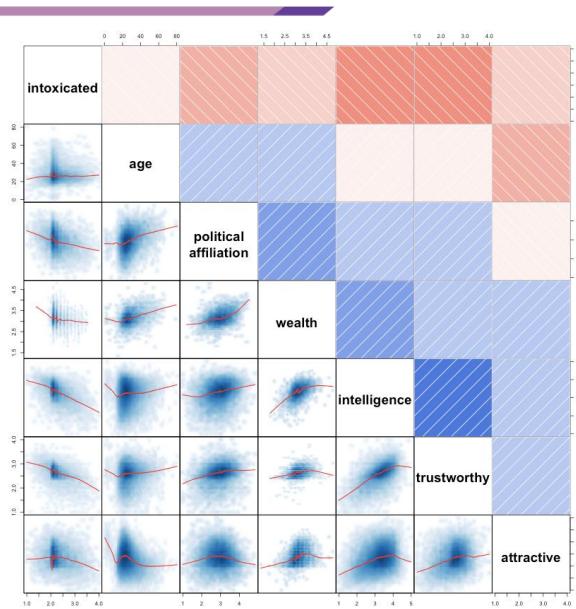
The Value of Visualization

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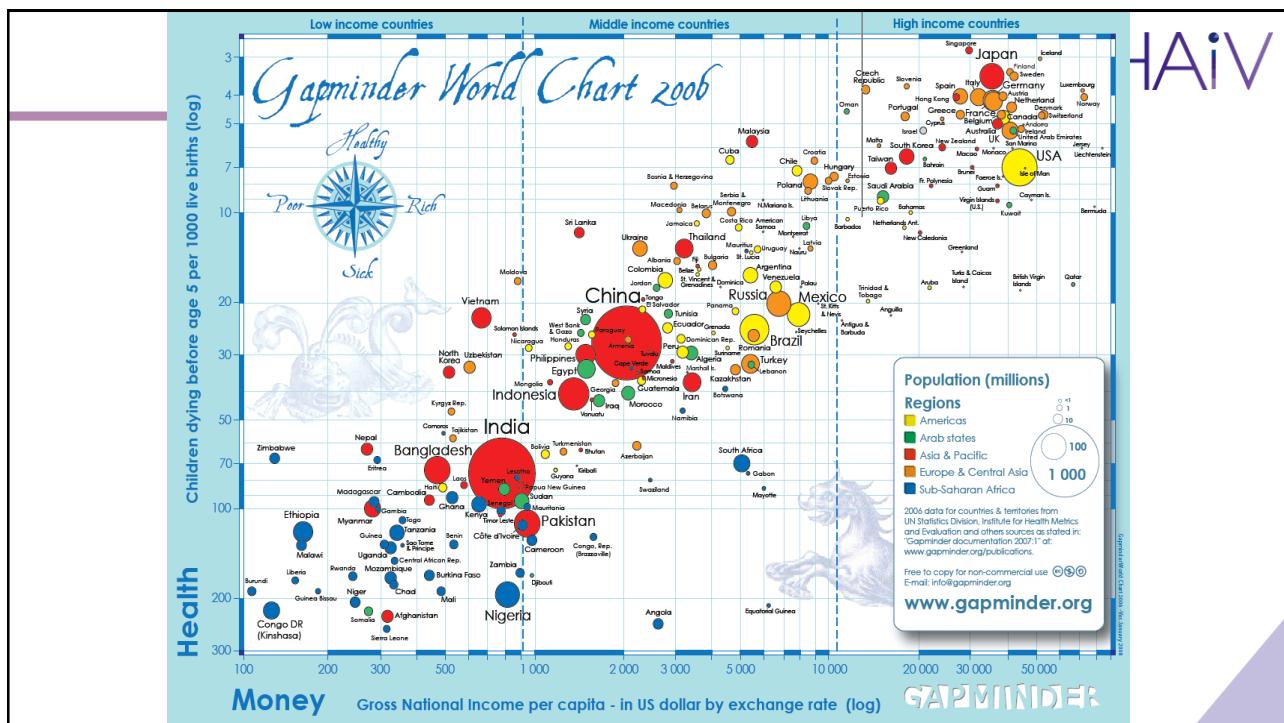
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Scatterplots and Scatterplot Matrices

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Making Decisions

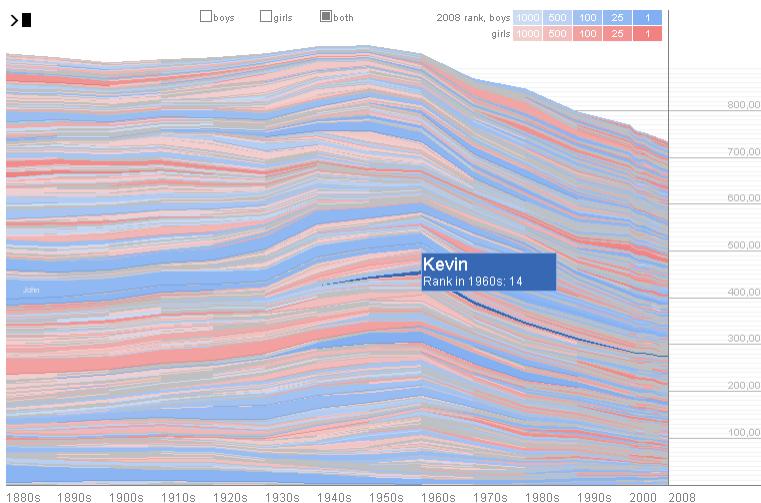
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Example: BabyNameExplorer

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

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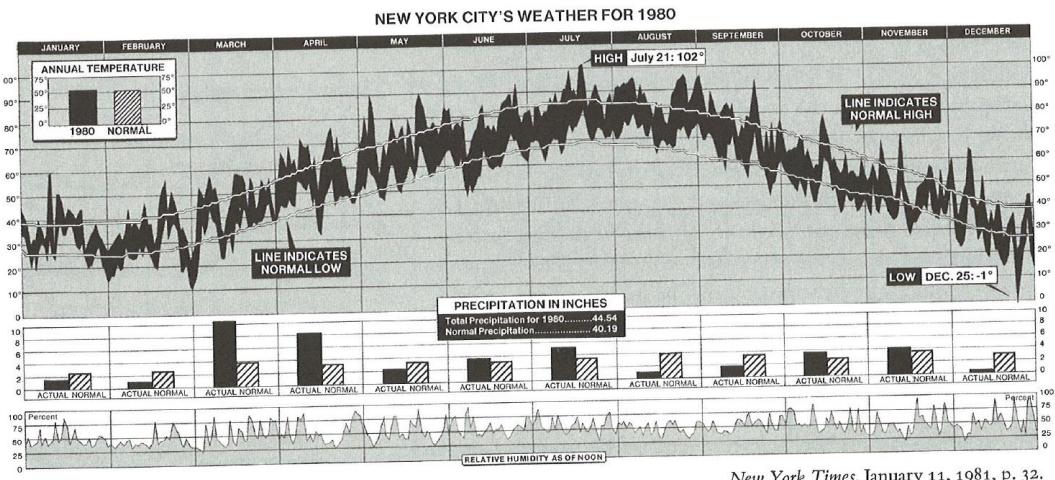
Find Patterns

The Value of Visualization

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Tell a Story

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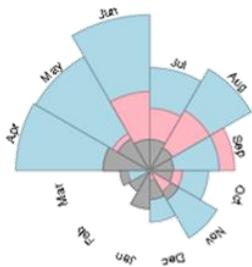
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Nightingale's Roses

[Bostock and Heer, 2009]

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DIAGRAM OF THE CAUSES OF MORTALITY
IN THE ARMY OF THE EAST

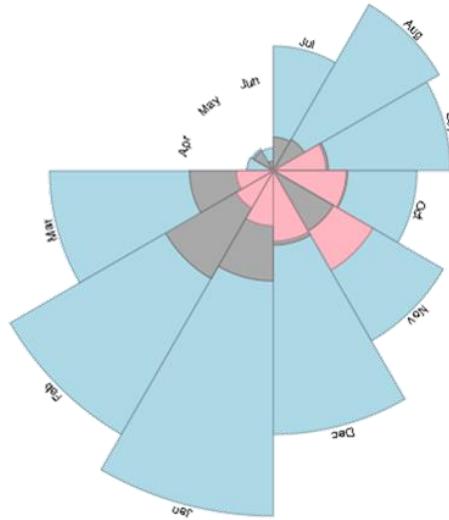


The Areas of the blue, red, & black wedges are each measured from the centre as the common vertex.

The blue wedges measured from the centre of the circle represent area for area the deaths from Preventible or Mitigable Zymotic Diseases, the red wedge measured from the center the deaths from wounds, & the black wedges measured from the center the deaths from all other causes

In October 1844, & April 1855, the black area coincides with the red, in January & February 1856, the blue coincides with the black

The entire areas may be compared by following the blue, the red & the black lines enclosing them.

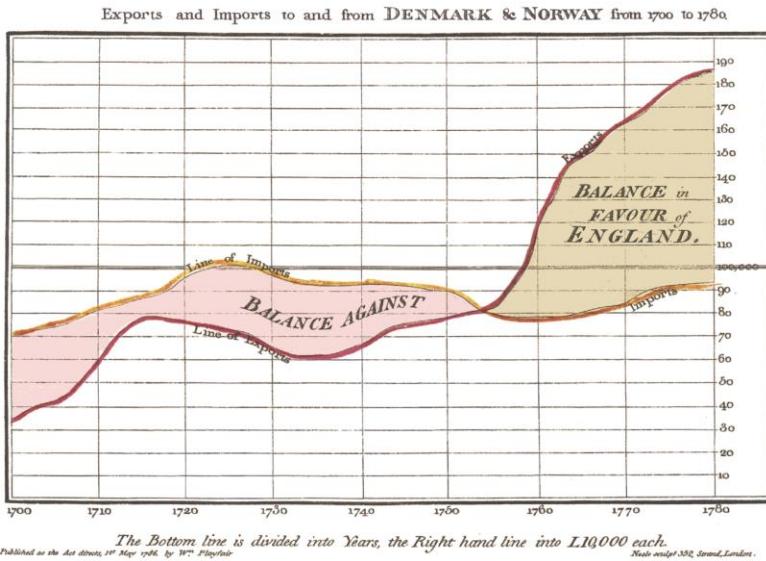


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[Playfair, 1785]

Example: William Playfair (1759-1823)

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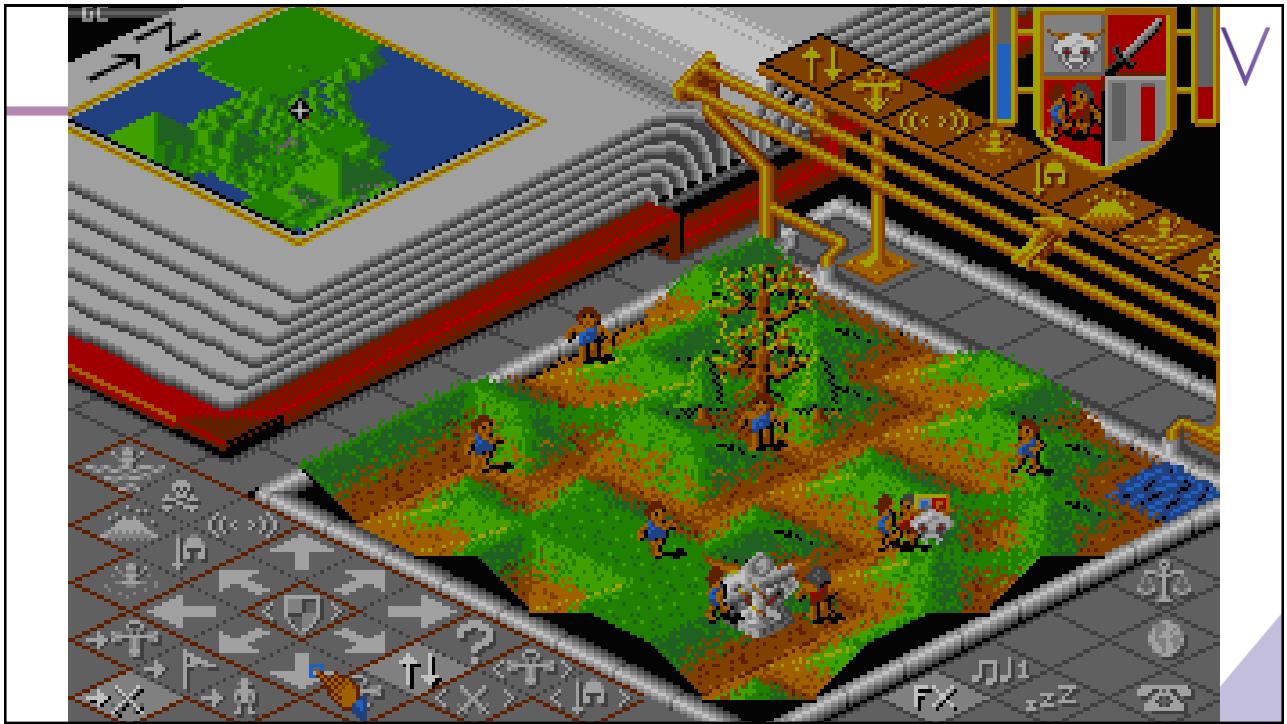
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Visualization In Games

The Value of Visualization

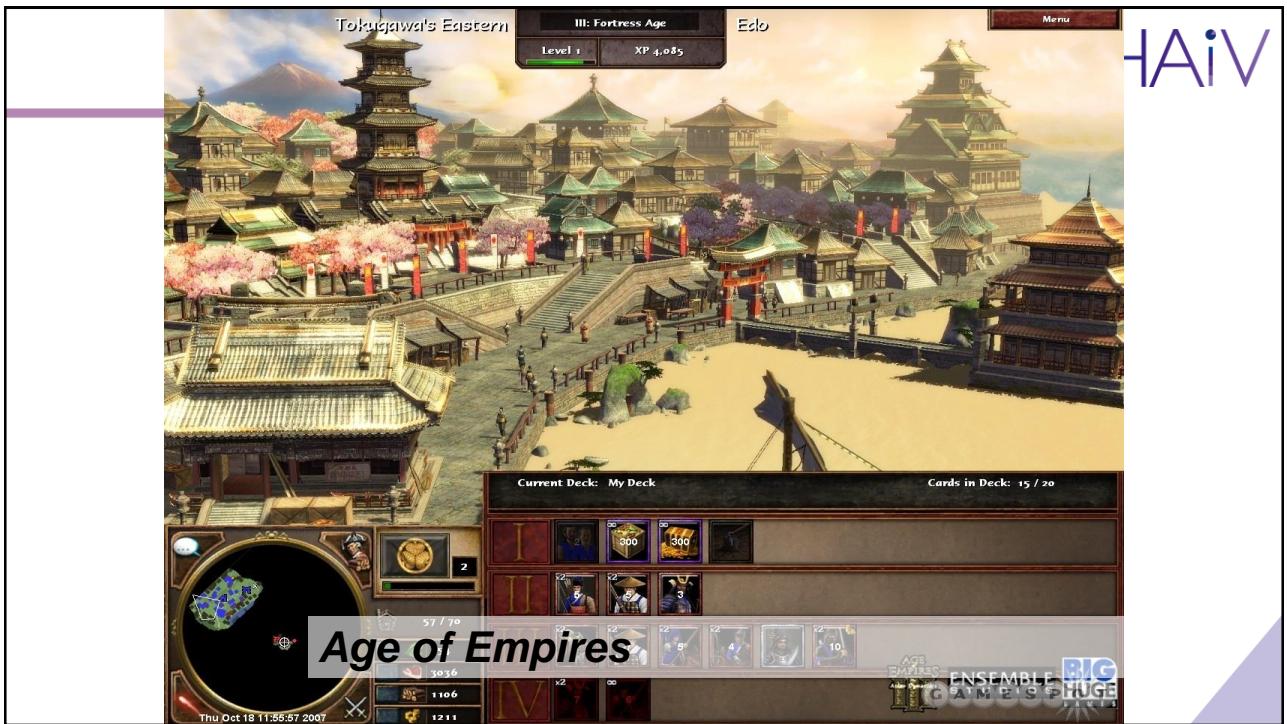
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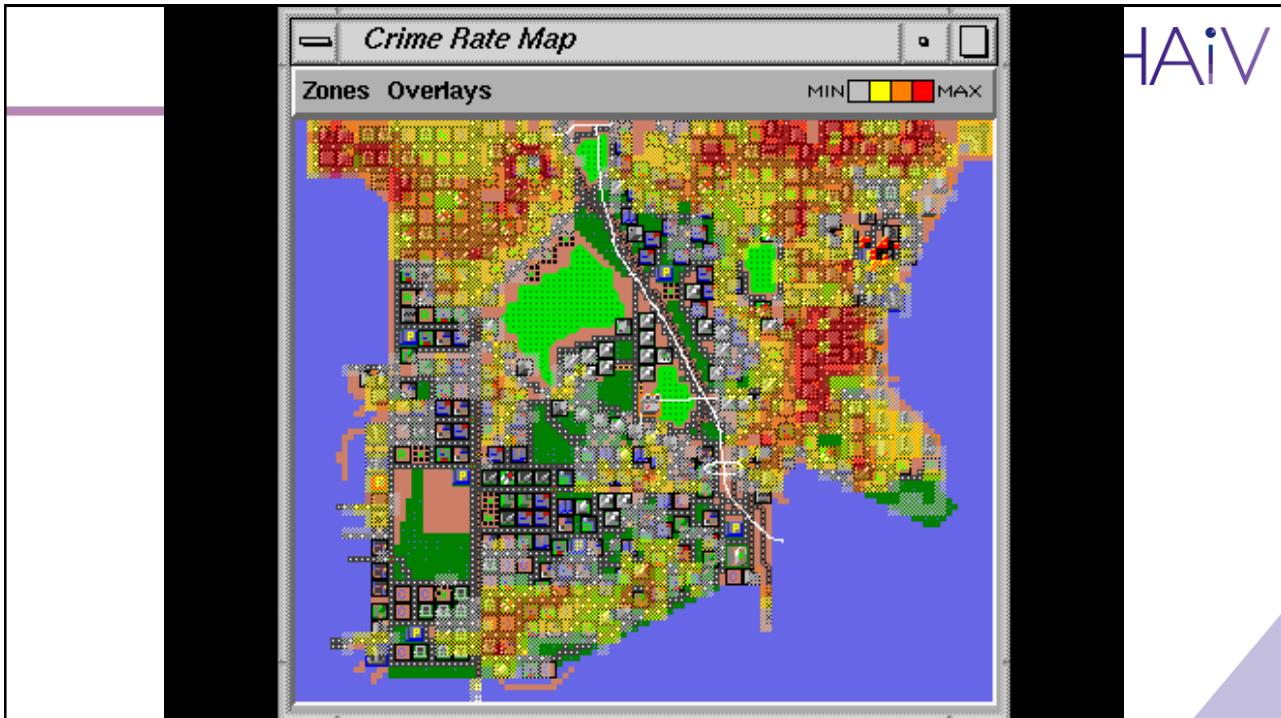
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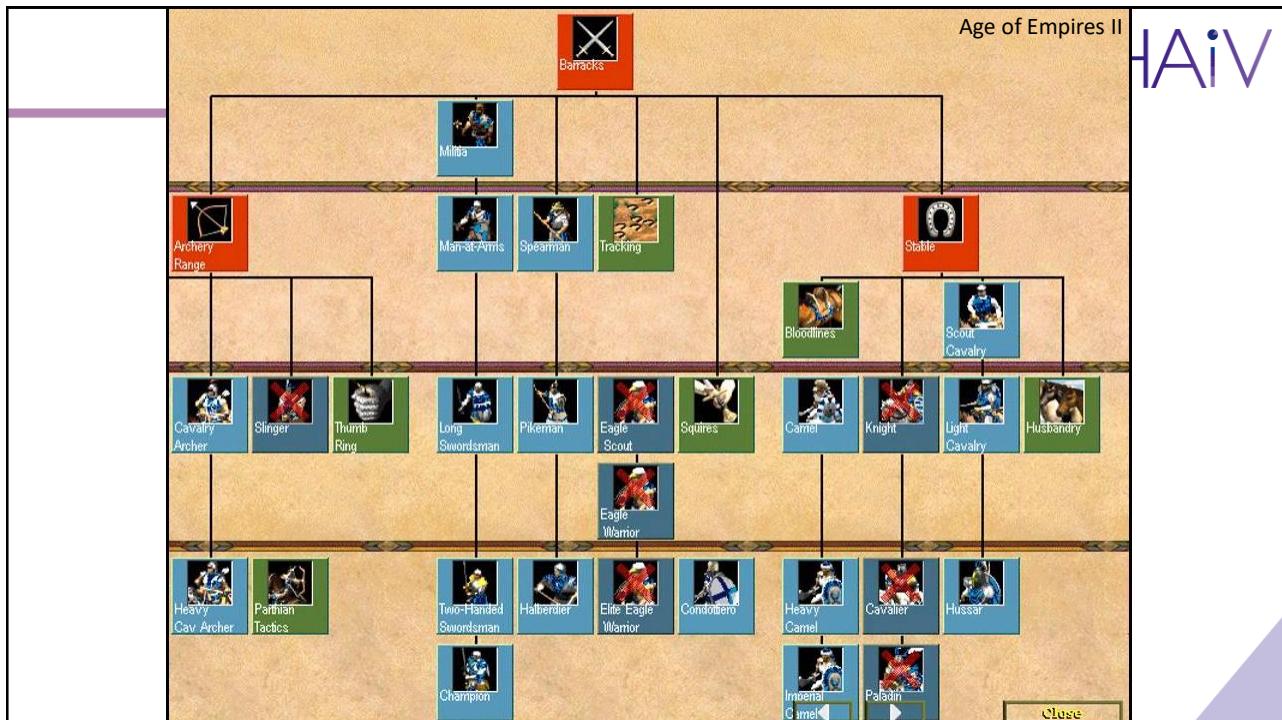
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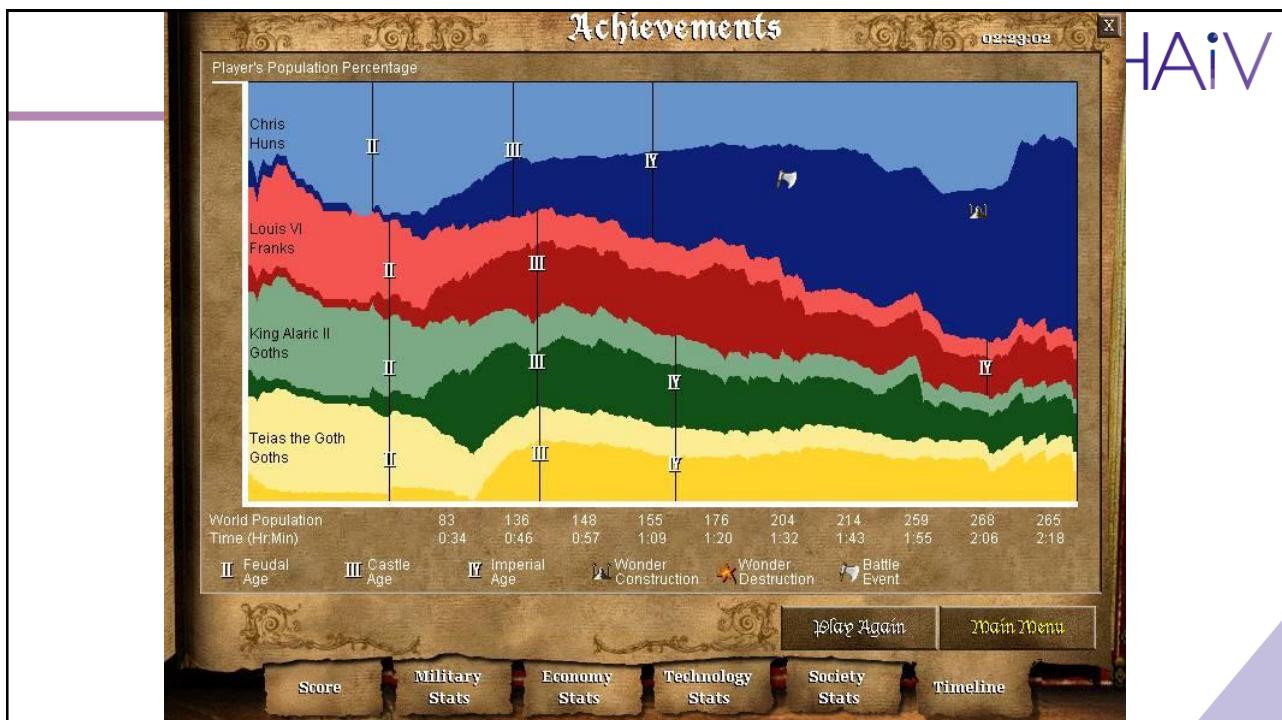
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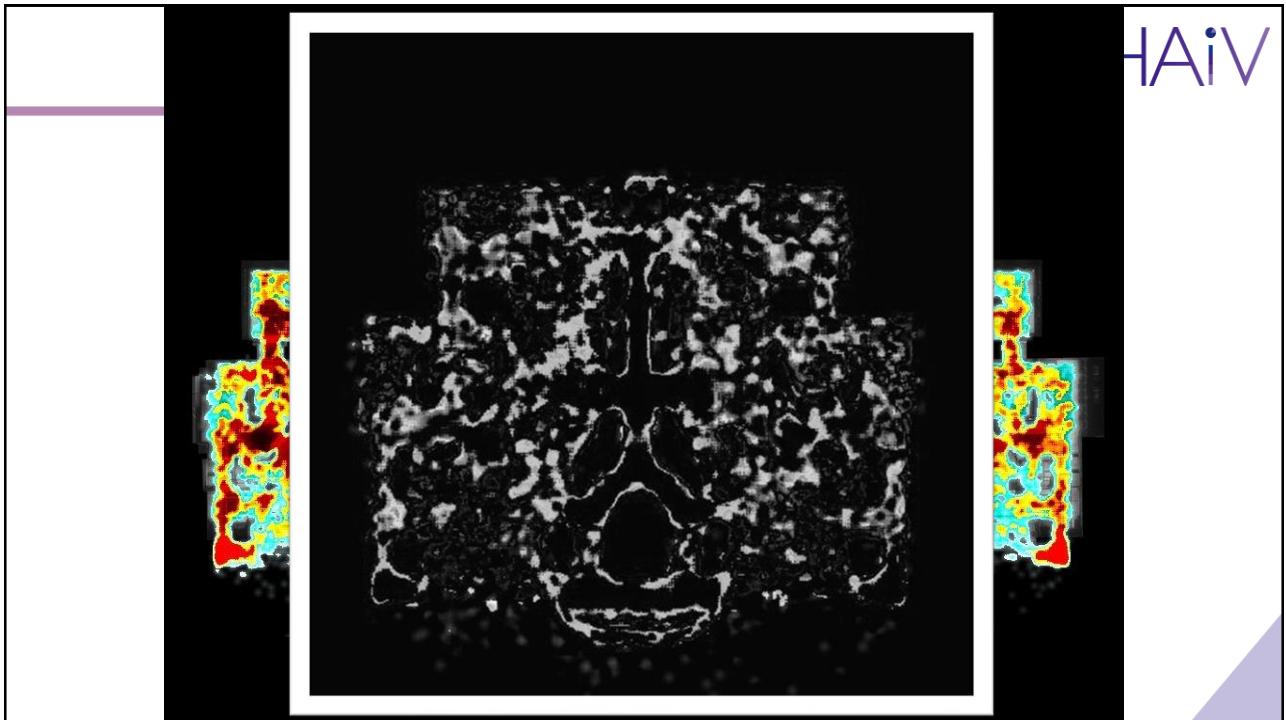
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Visualization In Media

The Value of Visualization

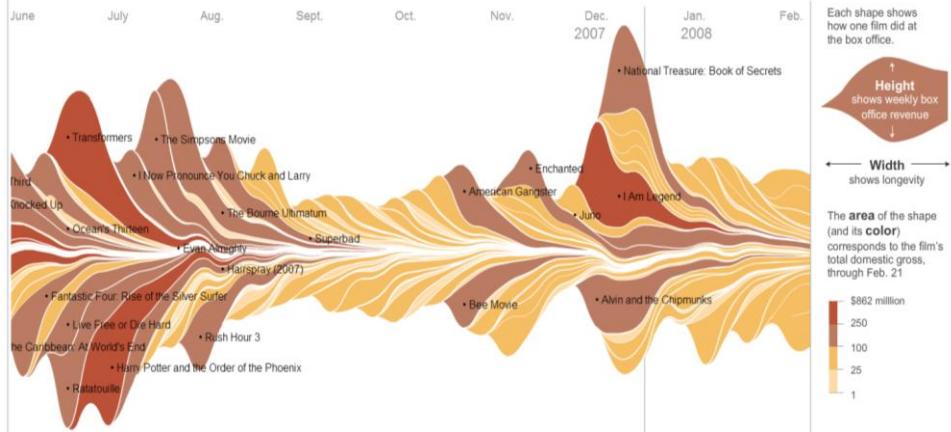
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http://www.nytimes.com/interactive/2008/02/23/movies/20080223_REVENUE_GRAPHIC.html

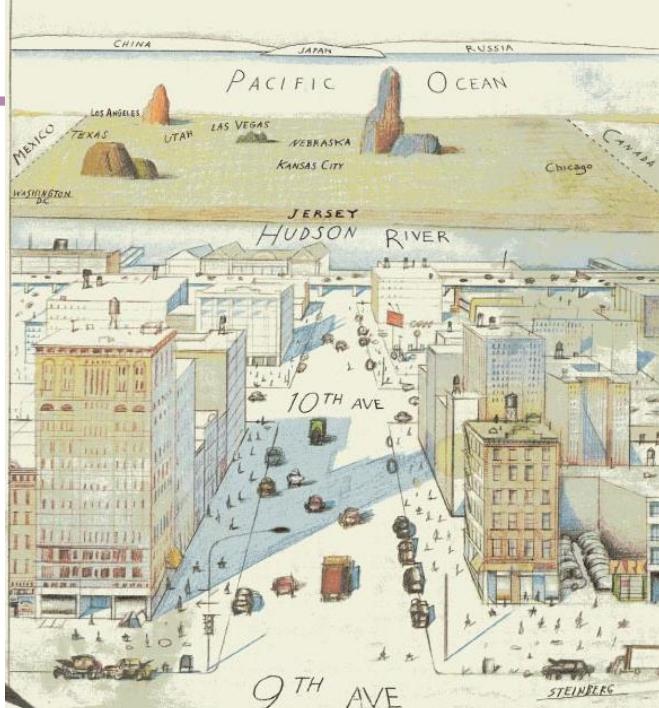
Box Office (1986-2008)

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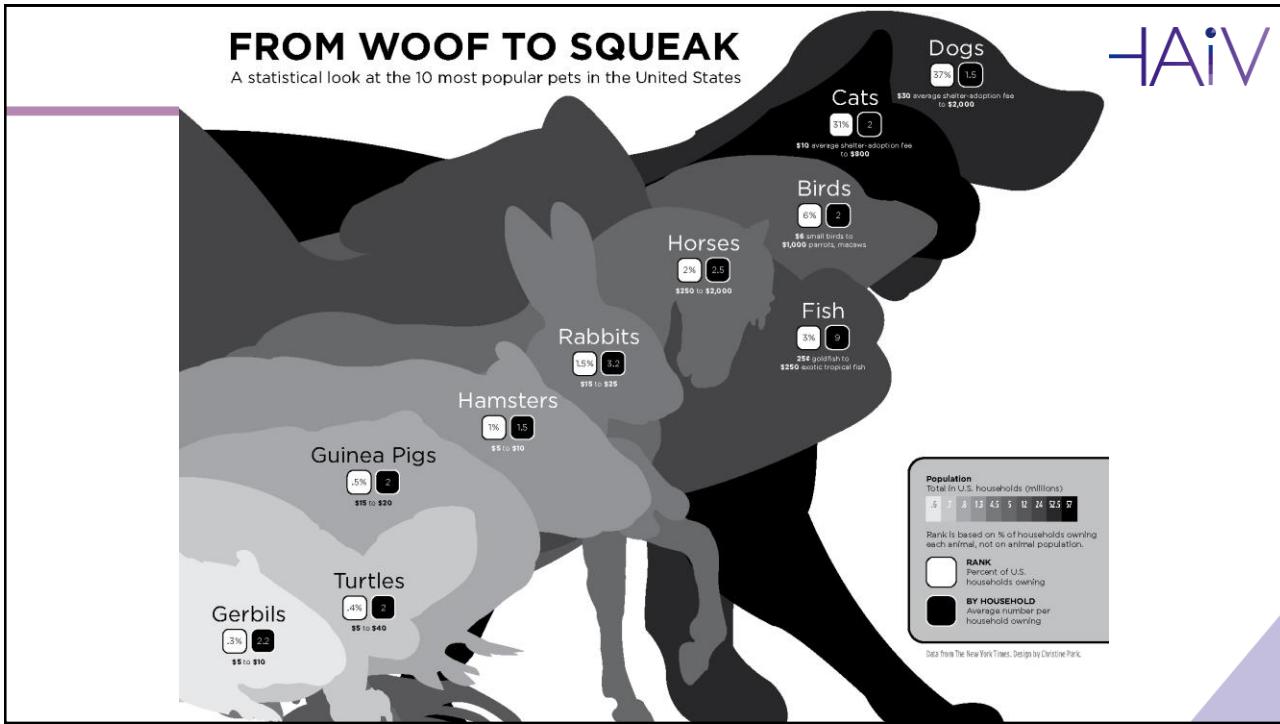
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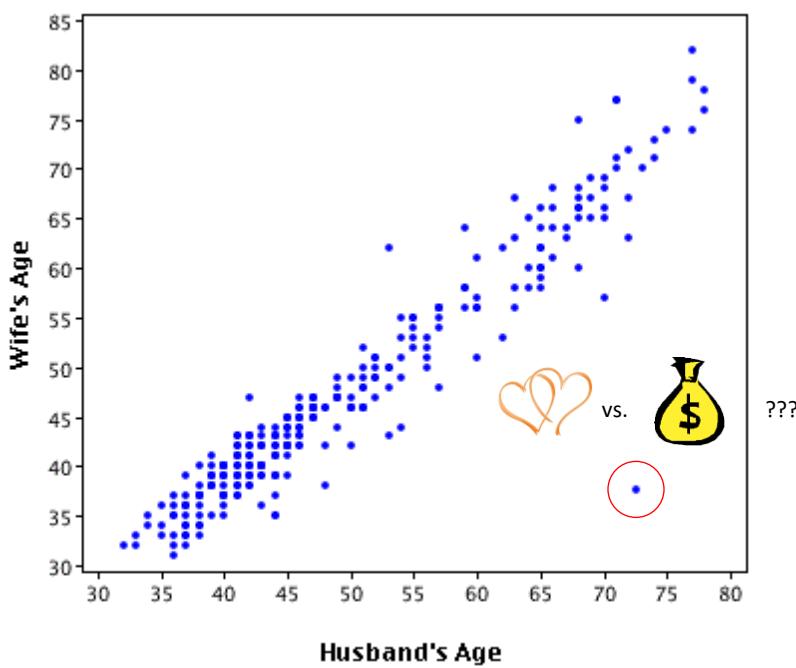
The Power of Visualization

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- The goal is to take all of this *data* and transform it into *information*
- How many terabytes of data we have collected doesn't matter, it's how many petaflops of *insights* we can generate from this data
- *"The purpose of computing is insight, not numbers."*
Dedication to his book: RW Hamming (1971).
Introduction to Applied Numerical Analysis. McGraw Hill.
- We need to make the data understandable to people and a key way of doing this is through *visualization*

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A	B	C	D
1 Animal	Brain Weight (kg)	Body Weight (kg)	
2 Mountain beav	1.35	465	
3 Cow	465	423	
4 Grey wolf	36.33	119.5	
5 Goat	27.66	115	
6 Guinea pig	1.04	5.5	
7 Diplodocus	11700	50	
8 Asian elephant	2547	4603	
9 Donkey	187.1	419	
10 Horse	521	655	
11 Potar monkey	10	115	
12 Cat	3.3	25.6	
13 Giraffe	529	680	
14 Gorilla	207	406	
15 Human	62	1320	
16 African eleph	6654	5712	
17 Triceratops	9400	70	
18 Rhesus monke	6.8	179	
19 Kangaroo	35	56	
20 Golden hamste	0.12	1	
21 Mouse	0.023	0.4	

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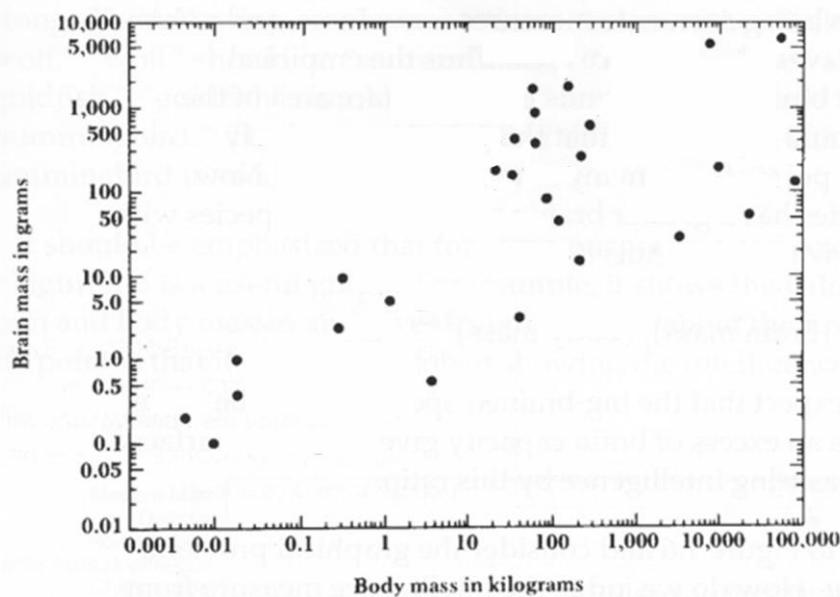
Which animal weights the least/most?
 Is there a relationship between brain weight and body weight?
 If so, are there any outliers?

Rousseeuw, P.J. & Leroy, A.M. (1987) Robust Regression and Outlier Detection. Wiley, p. 57

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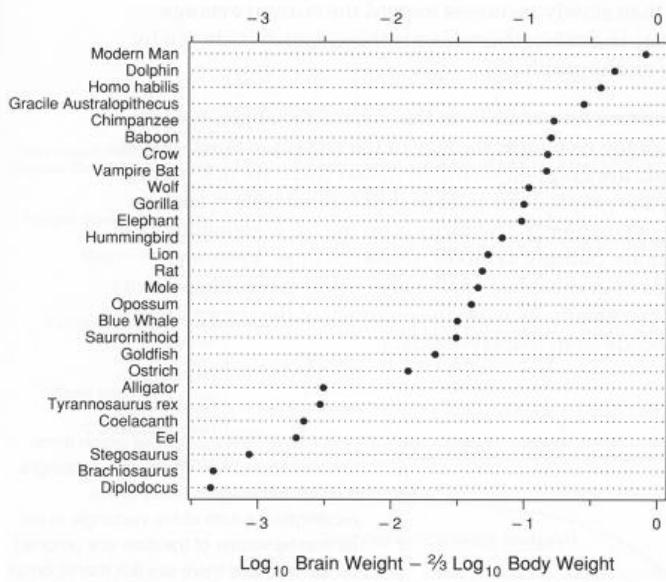
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WS Cleveland – The Elements of Graphing Data, 1994

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Visualization Through the Ages

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- Hand-drawn illustration¹ of water by Leonardo da Vinci from his studies to determine the processes underlying water flow (1510)



1 – Leonardo da Vinci. Old Man Seated on Rocky Outcrop, Seen in Profile to the Right, with Water Studies. Windsor Castle, Royal Library, R L 12579r, c. 1510-1513.

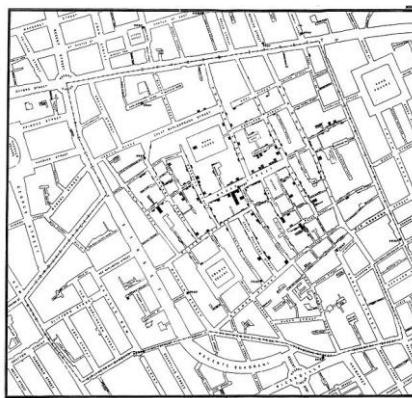
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Visualization Through the Ages

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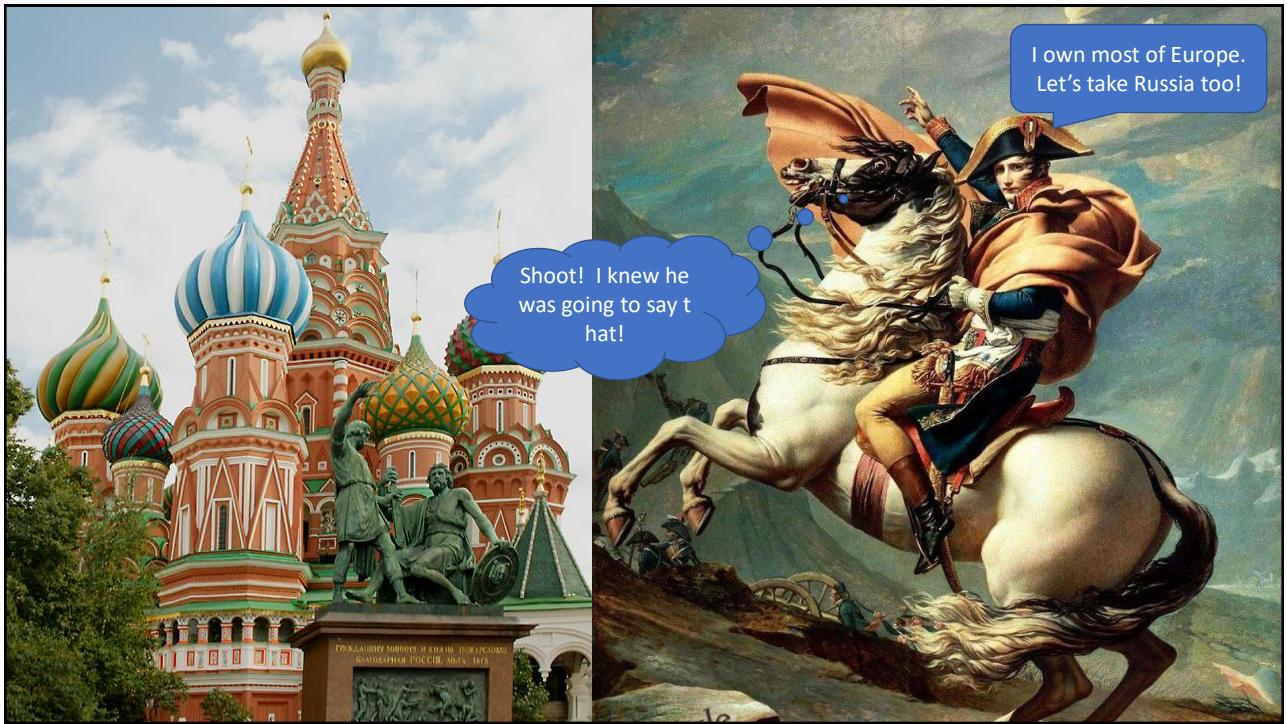
- John Snow's map of Cholera cases in the London epidemic of 1854¹



1 – The Visual Display of Quantitative Information, E. R. Tufte, 1983

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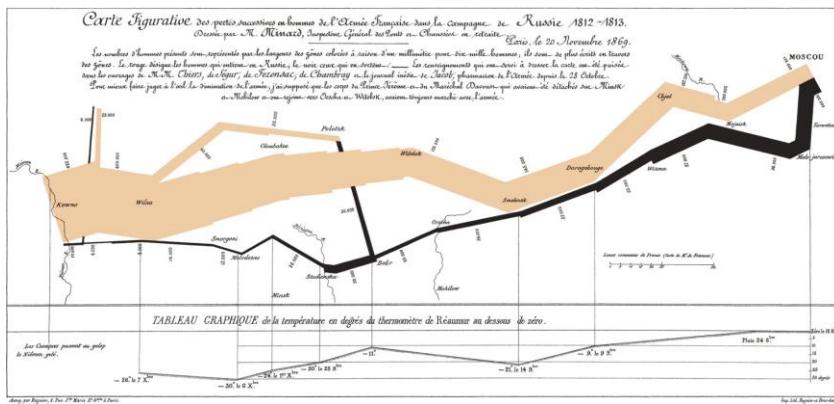


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Visualization Through the Ages

Haiv

- Charles Minard's 1869 flow map¹ showing Napoleon's disastrous Russian campaign of 1812.



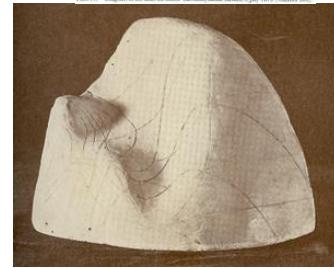
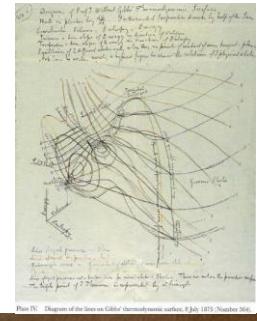
1 – Charles Joseph Minard: Mapping Napoleon's March, 1861 by John Corbett, Center for Spatially Integrated Social Science

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Visualization Through the Ages

HAiV

- James Maxwell's¹ thermodynamic surface sculpture (1874)
- Three-dimensional plot of the states of a fictitious water-like substance
- Coordinates are volume (x), entropy (y), and energy (z)



1 – James Clerk Maxwell and P. M. Harman (2002), The Scientific Letters and Papers of James Clerk Maxwell, Volume 3: 1874-1879, Cambridge University Press

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Visualization Through the Ages

HAiV

- 1936 *American Journal of Cancer XXVII*. P. 49: “The hexagonal tube ... offers distinct advantages with its flat sides permitting good visualization”
- 1973 *Nature* 17 Aug. P. 410-11: “Direct visualization of biological material at this level would tell us much about the structure and mode of action macromolecules.”
- Visualization in Scientific Computing ACM SIGGRAPH Computer Graphics, 21(6) – Special Issue, 1987.

1 – The first two citations on this page are borrowed from Pat Hanrahan's "The Purpose of Visualization" lecture: <http://graphics.stanford.edu/courses/cs448b-04-winter/lectures/purpose/walk003.html>

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Why is Visualization Helpful?

HAiV

- It utilizes the high bandwidth of the human visual systems
- The human mind is fast and parallel
- Humans are great at visual pattern recognition
- We have pre-attentive visual phenomena
- Visual tools can extend memory and cognitive capacity
- We think visually!
- “A picture is worth a thousand words.” – *Printers Ink*, pp. 96-97 December 8, 1921

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Is a Picture Worth a Thousand Words?

HAiV

- Diagrams have relationships defined within them (topological and geometric)
- Information can be indexed and ordered in logical sequences
- Information is processed differently when presented in textual form as opposed to diagrammatically
- Diagrams have the ability to group information spatially which can reduce the search process as well as support perceptual inferences where are difficult to make from text

1 - Larkin, J. & Simon, H. (1987) Why a diagram is (sometimes) worth ten thousand words. Cognitive Science, 11:65-992

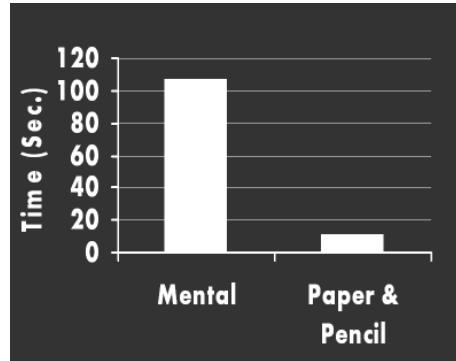
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Let's Exercise Our Brain

HAiV

$$\begin{array}{r}
 207 \\
 \times 52 \\
 \hline
 414 \\
 10350 \\
 \hline
 10764
 \end{array}$$



1 – The image on this page is borrowed from Pat Hanrahan's "The Purpose of Visualization" lecture: <http://graphics.stanford.edu/courses/cs448b-04-winter/lectures/purpose/walk003.html>

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Why Is Visualization So Helpful?

HAiV

- **Amplifies cognition**
 - Expands our working memory by allowing us to offload results
 - Reduces the search time
 - Pattern detection and recognition can be improved through perceptual cues and inference
 - Visualizations can be designed to control attention interaction for improving cognition

Readings in Information Visualization: Using Vision to Think, SK Card, J Mackinlay and B. Shneiderman, 1999

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Visualization: Definition

HAiV

- **Anyone?**
- **Components:**
 - Data
 - Graphics
 - Interaction
 - Human
 - Computer
 - Analysis
 - Algorithms

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Visualization – Definition?

HAiV



- **Wikipedia:** Visualization is any technique for creating images, diagrams, or animations to communicate a message.
- **M-W.com:** the act or process of interpreting in visual terms or of putting into visible form.



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Visualization – Definition!

HAiV

- “Transformation of the symbolic into the geometric”
 - [McCormick et al. 1987]
- “... finding the artificial memory that best supports our natural means of perception.”
 - [Bertin 1967]
- “The use of computer-generated, interactive, visual representations of data to amplify cognition.”
 - [Card, Mackinlay, & Shneiderman 1999]

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Visualization – Definition!

HAiV

- Focus on Card, Mackinlay & Shneiderman’s version...
- **Visualization** is the graphical representation of data using interactive images to aid cognition
 - Graphical + images: computer graphics
 - Interactive: human-computer interaction
 - Cognition: understanding, mental model

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What is Visualization?

HAiV

- “The use of computer-supported, interactive visual representations of data to amplify cognition.”¹
- This is not simply the process of making a graphic or an image, the goal is to create insight, not pretty pictures
- We want to help people form a mental image of something and internalize their own understanding
- We want to promote discovery, decision making and explanations

¹-Readings in Information Visualization: Using Vision to Think, SK Card, J Mackinlay and B. Schneiderman, 1999

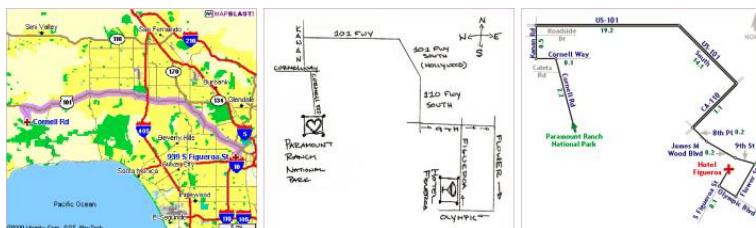
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What is Visualization

HAiV

- We want to find and utilize cognitive and perceptual principles
- We want to optimize our visualizations and our interactions with the visualization according to these principles



Maneesh Agrawala, Chris Stolte: Rendering effective route maps: improving usability through generalization. SIGGRAPH 2001: 24
1-249

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Scientific Visualization

HAiV

- Primarily relates to and represents something physical or geometrics
- The structure of the data is typically defined or given
- Examples
 - Air flow over a wing
 - Stresses on a girder
 - Organs in the human body
 - Molecular bonding

1 – Descriptions on this slide are borrowed from John Stasko's "InfoVis Overview" lecture: <http://www.cc.gatech.edu/~stasko/7450/Notes/oview.pdf>

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Information Visualization

HAiV

- Primarily relates to data that does not have a direct physical correspondence
- Notion of the data is abstract
- Examples
 - Baseball statistics
 - Stock trends
 - My social network

1 – Descriptions on this slide are borrowed from John Stasko's "InfoVis Overview" lecture: <http://www.cc.gatech.edu/~stasko/7450/Notes/oview.pdf>

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InfoVis vs. SciVis

HAiV

- **If data has some natural 2D or 3D form**
 - Scientific data -> **scientific visualization**
 - **Example:** air flow around space shuttle, CAT scan data, ocean temperature readings
- **If data is abstract**
 - Abstract data -> **information visualization**
 - **Example:** multidimensional database, text, trees, graphs

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InfoVis vs. SciVis

HAiV

- **Most differentiated by communities**
 - SciVis people from computer graphics background
 - InfoVis people from HCI background

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Purpose of Visualization

HAiV

- **Analysis – Understand your data better and act upon that understanding**
 - Given a data set, compare, contrast, assess, evaluate
 - Solve a problem!
- **Presentation – Communicate and inform others more effectively**
- **Visualization is most useful in exploratory data analysis¹**

1 – J. W. Tukey. Exploratory Data Analysis

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HAiV

“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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The Information Seeking Mantra

HAiV

Overview first,
then zoom and filter,
details on demand

1 - B. Schneiderman. *The Eyes Have It: A Task by Data Type Taxonomy for Information Visualizations*. In the Proceedings of the IEEE Symposium on Visual Languages, pp. 336-343, 1996.

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Tasks for Visualization

HAiV

- **Searching and browsing** - find a specific piece of information, inspect data, seek information
- **Analyze** – do comparisons, differences, look for outliers, extrema and patterns
- **Monitor** – look for changes and trends

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“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. S. Cleveland

The Elements of Graphing Data

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Visual Analytics

- **Visualization is good for exploring data, but we can do more than just explore**
- **“Visual analytics is the science of analytical reasoning facilitated by interactive visual interfaces”¹**
- **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.²**

¹ - J. J. Thomas and K. A. Cook (Ed.). *Illuminating the Path: The R&D Agenda for Visual Analytics*. National Visualization and Analytics Center, 2005.

² – Keim et al. chapter in *Information Visualization: Human-Centered Issues and Perspectives*, 2008.

3 – H. Wainer. *A Graphic Discovery: A Trout in the Milk and Other Visual Adventures*.

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Visual Analytics

HAiV

- “A graphic display has many purposes but it achieves its highest value when it forces us to see what we were not expecting.”³

1 - J. J. Thomas and K. A. Cook (Ed.). *Illuminating the Path: The R&D Agenda for Visual Analytics*. National Visualization and Analytics Center, 2005.
 2 – Keim et al. chapter in *Information Visualization: Human-Centered Issues and Perspectives*, 2008.
 3 - H. Wainer. *A Graphic Discovery: A Trout in the Milk and Other Visual Adventures*.

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Challenges in Visualization

HAiV

- **Scale**
 - Challenge often arises when data sets become large
- **Diversity**
 - Data is of varying types, forms, sizes
- **Evaluation**
 - How can we prove that a visualization helped?
 - Benefits are not easily quantifiable and measured.

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What will this course cover?

HAiV

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Data Representations

HAiV

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VALEUR		— —	— —	— —	— —
		LES VARIABLES DE SÉPARATION DES IMAGES			
		13			
GRAIN		— —	— —	— —	— —
COULEUR		— —	— —	— —	— —
ORIENTATION		— —	— —	— —	— —
FORME		— —	— —	— —	— —

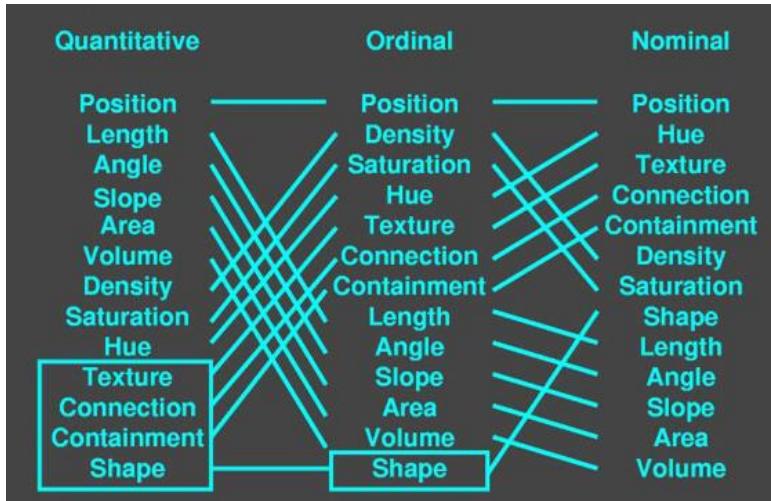
J Bertin. The Semiology of Graphics

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Perception and Cognition

Haiv



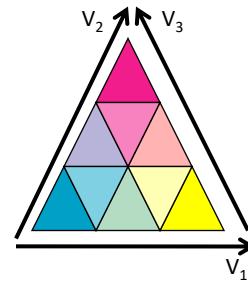
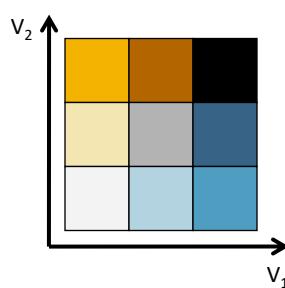
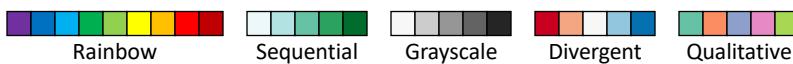
J Mackinlay. Automating the Design of Graphical Presentations of Relational Information, ACM TOG 5:2, 1986.

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Color

Haiv



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Interaction

"The capacity of vibrissae, hairs, claws, and horns to feel things at a distance is not different in principle from the ability of a man to use a cane or probe to detect the mechanical encounters at the end of the artificial appendage to his hand. The use of tools, from sticks, clubs, and rakes to more elaborate ones like screwdrivers and pliers or even fishing rods and tennis rackets, is probably based on a perceptual capacity of the body that is found in other animals. The remarkable fact is that when a man touches something with a stick he feels it at the end of the stick, not in the hand. This is a difficulty for the theory of sensation-based perception; it requires some such postulate as the projecting of sensations outward from the body. But we entertain the hypothesis that information for the mechanical disturbance at the end of the stick is obtained by the hand as a perceptual organ, including information about the length and direction of the stick. The sensations in the hand itself are irrelevant. The surface of an organism, it should be remembered, is actually a boundary between the organism and its environment, and the boundary is not always or everywhere as clean-cut as the hairless human philosopher tends to think."

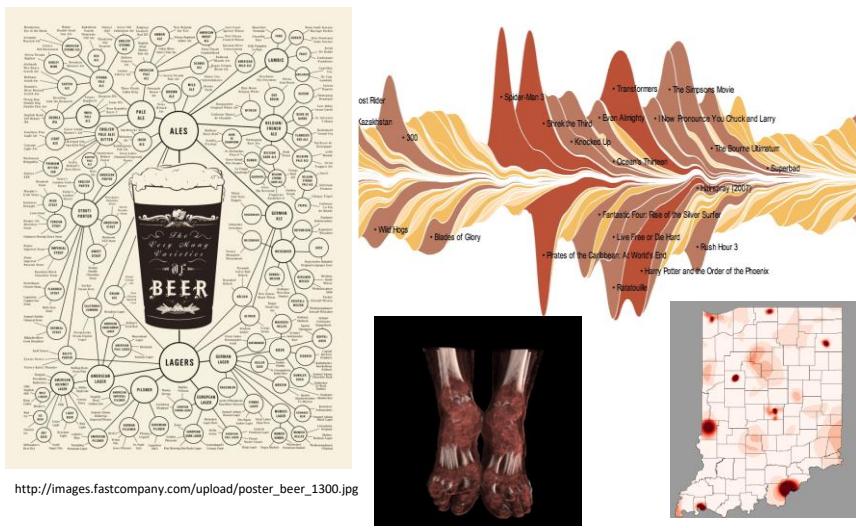
Gibson, J. J. The Senses Considered as Perceptual Systems. p.100-102]

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Visual Metaphors

HAIv



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

* - Theme River Image from: http://www.nytimes.com/interactive/2008/02/23/movies/20080223_REVENUGRAPHIC.html#

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More Examples?

HAiV

