



The Beauty and Joy of Computing

Lecture #16 Data and Information



"The Lost Language of Privacy"- Brooks

David Brooks waxes poetic about privacy in a NY Times piece about the pros/cons of police body cameras. He talks about why privacy is important to the development of full individuals, of families and friendships, and for communities.
Read it!



www.nytimes.com/2015/04/14/opinion/david-brooks-the-lost-language-of-privacy.html



Admin Notes

- Midterm tomorrow. Good Luck!
 - No Lecture
- "In-Lab" Portion:
 - 90 minutes
 - Take the survey
- Don't Stress!
 - Clobber Policy
- Next Week: "Explore" Post, a bit lighter.



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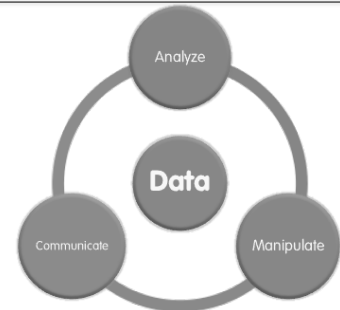


II

Data and Information



3 Components



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Data & Information Facilitate Knowledge

- Computers are used in an iterative and interactive way when processing digital information to gain insight and knowledge.
- Digital information can be filtered and cleaned by using computers to process information.
- Combining data sources, clustering data, and data classification are part of the process of using computers to process information.
- Insight and knowledge can be obtained from translating and transforming digitally represented information.
- Patterns can emerge when data is transformed using computational tools.



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A Human Component

- Collaboration, in working with data to gain insight and knowledge:
 - ...is an important part!
 - ...applies multiple perspectives, experiences, and skill sets.
 - ...involves communication between participants.
 - ...includes developing hypotheses and questions, and in testing hypotheses and answering questions.
 - ...can benefit from face-to-face and using online collaborative tools
 - ...when investigating large data sets can lead to insight and knowledge not obtained when working alone.



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bjc A Computational Component

- Large data sets
 - provide opportunities and challenges for extracting information and knowledge.
 - provide opportunities for identifying trends, making connections in data, and solving problems.
 - Need computing tools to facilitate the discovery of connections
- For efficiently finding, recognizing patterns and finding trends in information...
 - Search tools are essential.
 - Information filtering systems are important tools
 - Software tools, including spreadsheets and databases can help



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bjc Big Data Concerns

- Large data sets include data such as transactions, measurements, texts, sounds, images, and videos.
- The storing, processing, and curating of large data sets is challenging or sometimes impossible.
- Structuring large data sets for analysis can be challenging.
- Maintaining privacy of large data sets containing personal information can be challenging.
- Scalability of systems is an important consideration when data sets are large.
- Analytical techniques to store, manage, transmit, and process data sets change as the size of data sets scale.
- Technical problems affect how data set is used.**



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bjc Data is Ubiquitous

- ...we work with it all the time:
 - Data is collected any moment of your life
 - Data is stored, copied, transmitted, deleted, edited.
 - Computers perform operations on data
 - Data enters and exits through sensors
 - We can measure it!
 - 1 bit = '0' or '1'
 - 1 Byte = 8 bits
 - 1 KiB = 1024 Bytes, 1 MiB = 1024 KiB, 1 GiB = 1024 MiB, 1 TiB = 1024 GiB, 1 PiB = 1024 TiB, ...



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bjc How much is...?

- 1 KiB?
 - Long Paragraph of text (500-1,000 characters)
- 1 MiB?
 - 4 megapixel JPEG (compressed) image
 - .33 MP image UNcompressed
- 1 GiB?
 - One hour of standard def TV or 7 minutes of HDTV
- 1 TiB?
 - 2,000 hours of audio (uncompressed), 17,000 hours of MP3s
- 1 PiB?
 - Store the DNA of the entire population of the US – 3x!



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bjc Clicker Question

What do you think is the biggest data overall?

- Text
- Images
- DNA
- Videos
- Census Data



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II

Big Data, Compression, Metadata

bjc Big Data

- Netflix is said to use 1 PB to store the videos for streaming.
- World of Warcraft is stored on 1.3PB to maintain the game.
- Internet Archive: About 10PB
- AT&T transfers about 30PB of data through its networks each day.
- YouTube processes about 40PB of videos a day.
 - Multimedia data is the biggest data!
- Warning: may change! The internet is big...



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bjc Challenges

- Storage
 - No single hard disk/memory unit can store the data
 - Need to parallelize harddisks
 - All the problems of concurrent programming!
 - How to access the data?
 - What if a disk fails?
 - How fast is the access (read, write, delete)?
 - Physical limits: Energy cooling



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bjc Helpful Techniques: Lossless Compression

- Entropy compression reduces data volume by removing redundant information (so fewer bits are used to store or transmit it!)
- This compression is reversible but has mathematically proven limits.
- Example:

AAAAAABBBBBCCCC -> 6A5B3C



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bjc Helpful Techniques: Lossy Compression

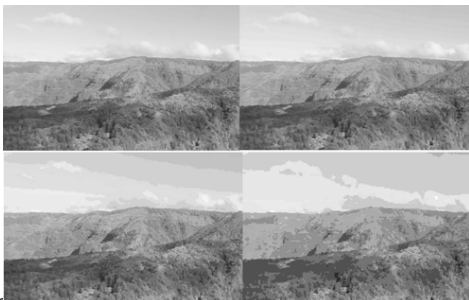
- Lossy compression reduces data volume by removing irrelevant information (and often can yield *smaller files* than lossless)
- This compression is not fully reversible but only has perceptual limits.
- There are trade-offs in using lossy and lossless compression techniques for storing and transmitting data.
- Compression needs an agreement on decompression = "format"



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bjc Lossy Compression Example: JPEG

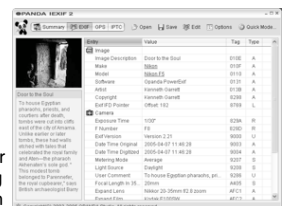


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bjc Techniques that help: Metadata

- Metadata: Data about data
 - can be descriptive data about an image, a Web page, or other complex objects.
 - can increase the effective use of data or data sets by providing additional information about various aspects of that data.
 - (e.g., search)



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bjc Main Reason for Digital Data

- Digital data can be copied without loss, and sent instantly, permanently to everyone.
 - Data is stored in many formats depending on its characteristics (e.g., size and intended use).
 - The choice of storage media affects both the methods and costs of manipulating the data it contains.
 - Reading data and updating data have different storage requirements.
- Problems with data that contains personal information:
 - Privacy
 - Security
- Trade-offs in storing, transmitting



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bjc Main Reasons for Big Digital Data

- Analyzing data at Internet-scale helps understand the world on never-before-seen scale.
- Useful for empirical sciences:
 - What are the economic trends based on Google searches?
 - Are there animals that dance to music without human training?
 - How is the flu progressing?
 - www.google.org/flu Trends/us/



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II

Data: Conclusions and Visualization

bjc Is Data the Solution to Everything?

- "Even" Internet data is biased
- It's easy to draw conclusions too quickly
- Sometimes finding the questions to ask is the hard part...
- E.g., Netflix Prize
 - "Predict whether someone will enjoy a movie based on how much they liked or disliked other movies"
 - Dataset: users and movie ratings
 - What questions can we ask of this data set?



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bjc en.wikipedia.org/wiki/Correlation_does_not_imply_causation! Correlation does not imply Causality!

- cum hoc ergo propter hoc logical fallacy:
 - A occurs in correlation with B.
 - Therefore, A causes B.
- Just because A and B are correlated does not necessarily imply one causes the other! It could be that...
 - A may be the cause of B
 - B may be the cause of A
 - some unknown third factor C may actually be the cause of A and B.
 - A caused B AND B caused A. This is a self-reinforcing system.
 - E.g., "predator-prey" relationships
 - the "relationship" is a coincidence or so complex or indirect that it is more effectively called a coincidence (i.e. two events occurring at the same time that have no direct relationship to each other besides the fact that they are occurring at the same time).



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bjc en.wikipedia.org/wiki/1854_Broad_Street_cholera_outbreak Benefits of Visualizations

- Visualization tools and software can communicate information about data
- To communicate effectively the insights and knowledge gained from digitally represented information
 - Summarize the data analyzed computationally
 - Transform the information
 - Tables, diagrams, and textual displays
- Interactivity with data is an aspect of communicating

John Snow's visualization of the outbreak of Cholera in 1854 London

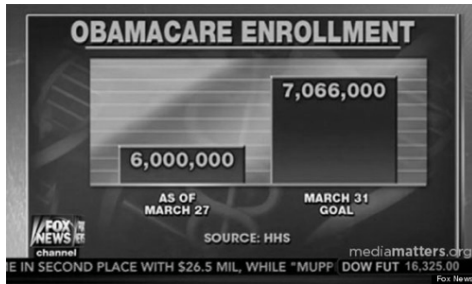


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Visualization ... Epic FAIL (2014)

www.huffingtonpost.com/2014/03/31/fox-news-obamacare-graphic_n_5063582.html

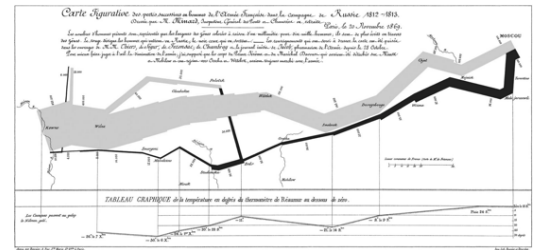


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Visualization ... Epic WIN (1869)

www.edwardtufte.com/tufte/posters



Charles Joseph Minard, Napoleon's 1812 Russian Campaign



UC Berkeley "The Beauty and Joy of Computing": Data (26)



Visualization ... Epic WIN (2009)

youtu.be/jbksRLYSojo

Additional Videos:
Short Visualizations:
<https://www.youtube.com/watch?v=QpdyCJi3lb4>
Full TED Talk:
http://www.ted.com/talks/hans_rosling_shows_the_best_stats_you_ve_ever_seen



Hans Rosling's 200 countries, 200 years, 4 minutes – the joy of stats



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Summary

- The right questions need to be answered by the proper data.
- The rewards are high but handling data is an ongoing challenge to computer scientists as well as security specialists and privacy preservers.



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Data & Information Facilitate Knowledge

- Computing enables and empowers new methods of information processing that have led to monumental change across disciplines, from art to business to science.
- Managing & interpreting an overwhelming amount of raw data is part of the foundation of our information society and economy.
- People use computers and computation to translate, process, and visualize raw data, and create information.
- Computation and computer science facilitate and enable a new understanding of data and information that contributes knowledge to the world.
- You will work with data using a variety of computational tools and techniques to better understand the many ways in which data is transformed into information and knowledge.



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