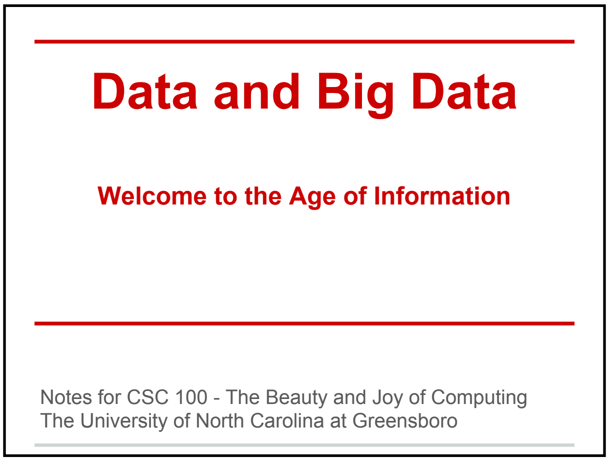
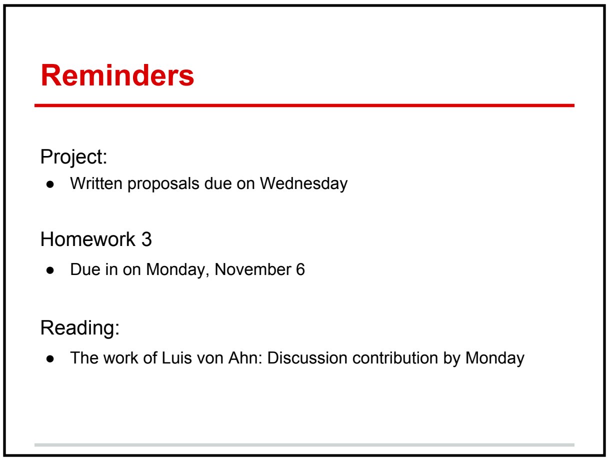


Data and Big Data

Welcome to the Age of Information

Notes for CSC 100 - The Beauty and Joy of Computing
The University of North Carolina at Greensboro



Reminders

Project:

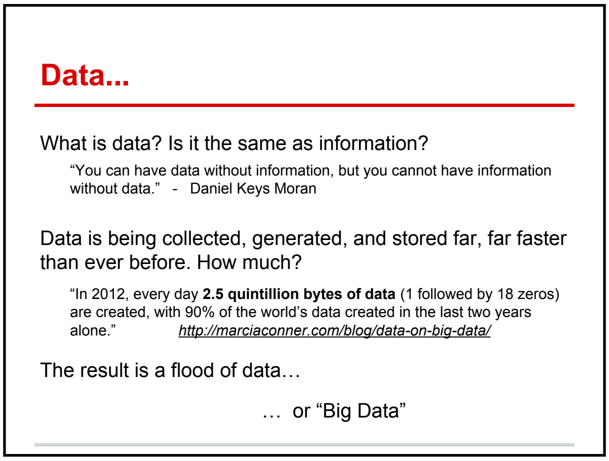
- Written proposals due on Wednesday

Homework 3

- Due in on Monday, November 6

Reading:

- The work of Luis von Ahn: Discussion contribution by Monday



Data...

What is data? Is it the same as information?

> "You can have data without information, but you cannot have information without data." - Daniel Keys Moran

Data is being collected, generated, and stored far, far faster than ever before. How much?

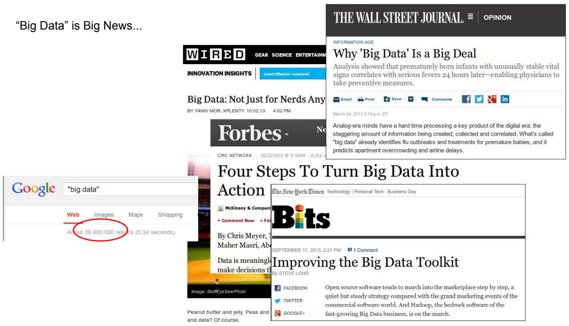
> "In 2012, every day **2.5 quintillion bytes of data** (1 followed by 18 zeros) are created, with 90% of the world's data created in the last two years alone." *http://marciaconner.com/blog/data-on-big-data/*

The result is a flood of data…

… or "Big Data"

Everyone is talking about “Big Data”

“Big Data” is Big News...



Google "big data"

Web Images Maps Shopping

About 39,400,000 results (0.34 seconds)

WIRED GEAR SCIENCE ENTERTAINM

INNOVATION INSIGHTS | contributor content

Big Data: Not Just for Nerds Any

BY YANIV MOR, XPLENTY 10.02.13 4:02 PM

Forbes Ne

CMO NETWORK | 10/22/2013 @ 9:31AM | 6,012 v

Four Steps To Turn Big Data Into Action

McKinsey & Company

+ Comment Now + Fol

By Chris Meyer, T Maher Masri, Abo

Data is meaningl make decisions t

Image: StuffEyeSee/Flickr

Peanut butter and jelly. Peas and and data? Of course.

THE WALL STREET JOURNAL. ≡ | OPINION

INFORMATION AGE

Why 'Big Data' Is a Big Deal

Analysis showed that prematurely born infants with unusually stable vital signs correlates with serious fevers 24 hours later—enabling physicians to take preventive measures.

Email Print Save Comments

March 24, 2013 5:13 p.m. ET

Analog-era minds have a hard time processing a key product of the digital era: the staggering amount of information being created, collected and correlated. What's called "big data" already identifies flu outbreaks and treatments for premature babies, and it predicts apartment overcrowding and airline delays.

The New York Times Technology | Personal Tech | Business Day

Bits

SEPTEMBER 17, 2013, 2:21 PM 1 Comment

Improving the Big Data Toolkit

By STEVE LOHR

FACEBOOK

TWITTER

GOOGLE+

Open source software tends to march into the marketplace step by step, a quiet but steady strategy compared with the grand marketing events of the commercial software world. And Hadoop, the bedrock software of the fast-growing Big Data business, is on the march.

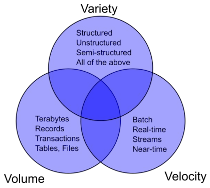
What does “Big Data” mean?

“Big Data” characterized by “three V’s”:

- **V**olume: How much data (lots!)
- **V**elocity: How fast does it arrive (and get processed)
- **V**ariety: Different sources, different types - text, images, …

Some people add a fourth “V”:

- **V**eracity: Quality of data



Volume: Measuring Data

The basic unit of information is a bit

… or a byte (usually 8 bits)

“usually”?!? Really? Really!!
Almost always 8 bits, but not always
When it’s important that we refer to 8 bits, the term used is “octet”

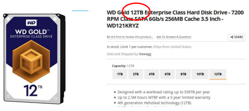
What is a kilobyte (kB)?
Memory (RAM) sizes must be a power of 2, so 1 kB was traditionally 2^{10}=1024 bytes
Different from SI units version of “kilo” (1000, as in kilometer, kilogram, …)
But it’s close!

So traditionally, 1 MB = 2^{20} bytes = 1,048,576 bytes ; 1 GB = 2^{30} B = 1,073,741,824 B
So off by over 7% for 1GB

Hard drive manufacturers revolted!
Wanted to advertise a 2^{29} B drive as 537 MB rather than 512 MB - back to SI units!

Now: RAM typically in power-of-two units (some suggest KiB/MiB/GiB for this), and persistent storage in SI units. What about flash drives? If it’s important, get clarification!

How much is...



WD Gold 12TB Enterprise Class Hard Disk Drive - 7200 RPM Class SATA 6Gb/s 256MB Cache 3.5 Inch - WD121KRYZ

Be the first to review this product... Ask Or Answer A Question

In stock. Limit 1 per customer. Ships from United States.

Sold and Shipped by Newegg

Capacity: 12TB

1TB 2TB 4TB 6TB 8TB 10TB 12TB

- Designed with a workload rating up to 550TB per year
- Up to 2.5M hours MTBF with a 5 year limited warranty
- 4th generation HelioSeal technology (12TB)

1kB?
- Paragraph of text

1MB?
- 4 megapixel JPEG-compressed image

1GB?
- 30 minutes of DVD-quality SD TV
- 3.5 minutes at Blu-ray HD rate

1TB?
- 2,000 hours of audio (uncompressed)
- 17,000 hours as MP3s (255,000 4-minute songs)

1PB?
- DNA of the entire population of the US - three times over!
- Two months data from the planned Large Synoptic Survey Telescope

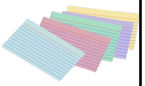
See also http://www.jamesshuggins.com/h/tek1/how-big.htm

A Flood of Data

Recall from "Organizing Data" lecture

Consider the amount of data we deal with:

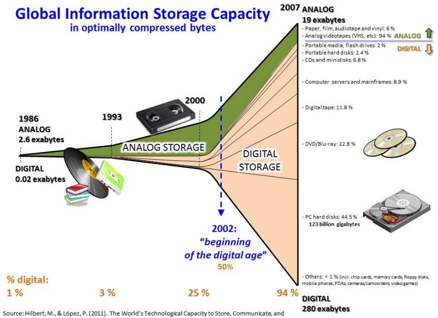
- Human genome: Just over 3 billion base pairs
  - *Typing in 12pt on 8.5x11 paper fits 2880 characters*
  - *So the human genome would be over a million pages (printed two-sided, an 86 foot high stack of paper)*
- Facebook - http://expandedramblings.com/index.php/by-the-numbers-17-amazing-facebook-stats/
  - *2.01 billion monthly active users (1.32 billion daily!)*
  - *Messenger+WhatsApp: Over 60 billion messages/day*
    - *On index cards, would be a stack 7500 miles high!*
  - *... or end-to-end would stretch around the world 180 times*



- Large Synoptic Survey Telescope
  - *16 terabytes (16,000,000,000,000 bytes) will be captured per day*
  - *Most of this data will never be seen by a human being*
- *Walmart customer transaction database*
  - *Estimated to be approximately 2.5 petabytes*

A Flood of Data

Another view...



Source: Hilbert, M., & López, P. (2011). The World's Technological Capacity to Store, Communicate, and Compute Information. *Science*, 332(6025), 60 –65. http://www.martinhilbert.net/WorldInfoCapacity.html

So much data available

Some publicly-available big datasets

Some examples of available data:

- data.gov
  - Over 130,000 datasets on Oct 26, 2014
  - Census data, USGS Topo maps, house price indexes, NOAA Geophysical Data Center, …
- Amazon web services public data sets (http://aws.amazon.com/datasets)
  - Web crawl of over 5 billion web pages
  - “1000 Genomes Project”
  - Japan Census Data
  - Google Books Ngrams
- UCI Machine Learning Repository (http://archive.ics.uci.edu/ml/datasets.html)
  - All sorts of data for machine learning experiments
- NCBI (http://www.ncbi.nlm.nih.gov/genome)
  - Genome information including sequences of many organisms
  - From the U.S. National Library of Medicine

Making sense out of data - processing

Data mining: Finding patterns

What do you do with lots of data - find patterns!

An old urban legend: *A supermarket analyzed purchasing data and found a correlation between purchases of diapers and beer that no one knew about. They put the two closer together in the store and….. profit!*

The real story: *Almost true… It was Osco Drug stores, not a supermarket. And while they found the correlation (between 5:00 and 7:00pm) they didn’t actually change anything as a result - that was just a “what if…” comment that became legend.*

There are certainly real stories that are even more astounding:

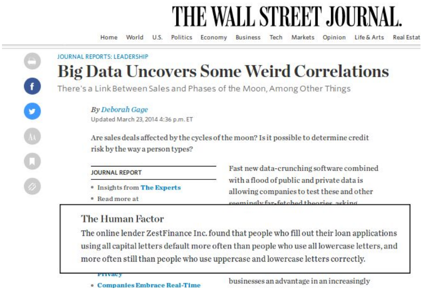
http://www.nytimes.com/2012/02/19/magazine/shopping-habits.html

From the story: “*As Pole’s computers crawled through the data, he was able to identify about 25 products that, when analyzed together, allowed him to assign each shopper a “pregnancy prediction” score. More important, he could also estimate her due date to within a small window, so Target could send coupons timed to very specific stages of her pregnancy.*”

See also: Video at the end of “Big Data” lectures.

Making sense out of data - processing

Data mining: Finding patterns



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JOURNAL REPORTS: LEADERSHIP

Big Data Uncovers Some Weird Correlations

There's a Link Between Sales and Phases of the Moon, Among Other Things

By Deborah Gage
Updated March 23, 2014 4:36 p.m. ET

Are sales deals affected by the cycles of the moon? Is it possible to determine credit risk by the way a person types?

JOURNAL REPORT

- Insights from The Experts
- Read more at
- Privacy
- Companies Embrace Real-Time

Fast new data-crunching software combined with a flood of public and private data is allowing companies to test these and other seemingly far-fetched theories, asking

businesses an advantage in an increasingly

The Human Factor

The online lender ZestFinance Inc. found that people who fill out their loan applications using all capital letters default more often than people who use all lowercase letters, and more often still than people who use uppercase and lowercase letters correctly.

Making sense out of data - processing

Tools and Technologies - Software

All the major tools are free / open source

Initial release in 2006

Based on Google technology

Main pieces:
- HDFS: Filesystem
- MapReduce: Processing
- YARN: Resource mgmt

“Data warehouse” solution

Originally from Facebook (2008)

Facebook’s implementation
- 150,000 tables
- 100 PB of storage

Cluster computing framework

Orig from UC Berkeley (2012)

10x-100x faster on some apps

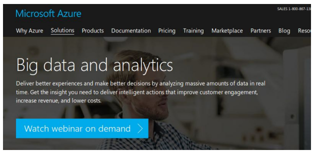
Making sense out of data - processing

Tools and Technologies - Hardware

Where to get such large computing resources? Lots of “cloud” resources to rent:

Amazon EMR

Easily Run and Scale Apache Hadoop, Spark, HBase, Presto, Hive, and other Big Data Frameworks



Big data and analytics

Deliver better experiences and make better decisions by analyzing massive amounts of data in real time. Get the insight you need to deliver intelligent actions that improve customer engagement, increase revenue, and lower costs.

Be one with your data

Introducing SDX. Experience your data whenever, wherever, and however you'd like.

Making sense out of data - viewing

Visualization

How can we view data? A couple of on-line examples:

D3: Data-Drive Documents

Technology allows interactive data presentation

Example: http://benschmidt.org/Degrees/

D3 toolkit: http://d3js.org/

Dataseed: View data along several dimensions

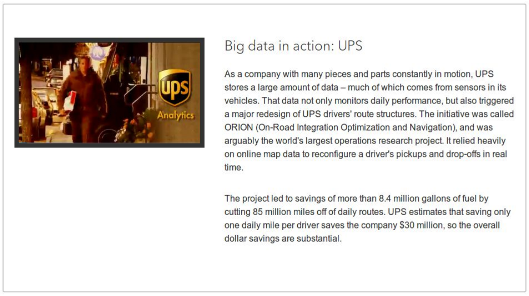
Demos: https://getdataseed.com/demo

Other viz tools:

http://selection.datavisualization.ch/

Utilizing Data

Why Companies Care….



Big data in action: UPS

As a company with many pieces and parts constantly in motion, UPS stores a large amount of data – much of which comes from sensors in its vehicles. That data not only monitors daily performance, but also triggered a major redesign of UPS drivers' route structures. The initiative was called ORION (On-Road Integration Optimization and Navigation), and was arguably the world's largest operations research project. It relied heavily on online map data to reconfigure a driver's pickups and drop-offs in real time.

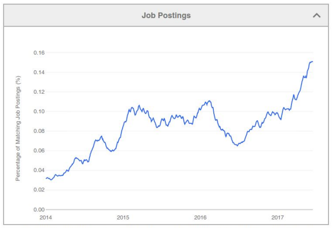
The project led to savings of more than 8.4 million gallons of fuel by cutting 85 million miles off of daily routes. UPS estimates that saving only one daily mile per driver saves the company $30 million, so the overall dollar savings are substantial.

From: https://www.sas.com/en_us/insights/big-data/what-is-big-data.html

Data Analytics / Data Science

A valuable and growth-area skill

Job postings for “Data Scientist” (5x increase in past 3 years):



Indeed searches millions of jobs from thousands of job sites. The jobseeker interest graph shows the percentage of jobseekers who have searched for "Data Scientist" jobs. The job postings graph shows trends for jobs containing "Data Scientist".

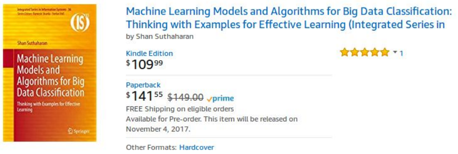
Valuable contests to demonstrate skills and develop techniques:

http://www.kaggle.com/

What’s happening at UNCG?

Dr. Suthaharan

- Over a decade of work in cluster computing / big data
- Wrote a very popular book on Big Data classification (over 60,000 downloads of e-book)


Integrated Series in Information Systems 36
Shan Suthaharan
Machine Learning Models and Algorithms for Big Data Classification
Thinking with Examples for Effective Learning
Springer

Machine Learning Models and Algorithms for Big Data Classification: Thinking with Examples for Effective Learning (Integrated Series in

by Shan Suthaharan

★★★★★ 1

Kindle Edition

$\$109^{99}$

Paperback

$\$141^{55}$ ~~$149.00~~ prime

FREE Shipping on eligible orders

Available for Pre-order. This item will be released on November 4, 2017.

Other Formats: Hardcover

- Has supervised >30 master’s student project/theses in past 5 years
- Teaches CSC 510 (Big Data and Machine Learning)

What's happening at UNCG?

Dr. Mohanty

Before UNCG: Was lead at the "Innovative Data Laboratory" at Mississippi State

Some past projects:

- Anomaly Detection in High Velocity Streaming Data
- Social Media Tracking and Analysis System
- Organic Social Media During Severe Weather Events
- Networks of Research

Teaches CSC 495 (Data Science)

Lambda "DevBox" - Deep Learning Machine

- 14,336 GPU computing cores
- > 40 Gbps memory throughput
- Machine learning software...

Summary

Main take-aways:

- More data than ever before being collected and used
- Must be able to manage the data
- Making sense out of the data is a very valuable skill
    - Analysis, mining, and visualization are all parts of this

What you should have gotten from this lecture:

- A sense for data sizes
- An idea of what data is out there: available and private
- Some ideas and pointers for how data is used

And finally… a video

Relevant information:

- *NY Times Magazine* story on data mining
  http://www.nytimes.com/2012/02/19/magazine/shopping-habits.html
- Forbes story "How Target Figured Out A Teen Girl Was Pregnant Before Her Father Did":
  http://www.forbes.com/sites/kashmirhill/2012/02/16/how-target-figured-out-a-teen-girl-was-pregnant-before-her-father-did/

The entertaining take:

http://www.cc.com/video-clips/dv9iqc/the-colbert-report-the-word---surrender-to-a-buyer-power