# The Beauty and Joy of Computing

**Lecture #10**
**Data**

UC Berkeley EECS
Lecturer
Gerald Friedland

**Bendable Displays!!!**

http://abcnews.go.com/Technology/lgs-flexible-screens-rolling-off-factory-lines/story?id=20498107

## Data: A Definition



## We don't really know what it is…

**…but we work with it all the time:**

- **Data is collected any moment of your live**
- **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'/'1'
  - 1 Byte = 8 bit
  - 1 kB = 1024 Bytes, 1MB = 1024kB, 1GB = 1024MB, 1TB=1024GB, 1PB=1024TB, 1EB=1024PB, …



## How much is?

- **1kB?**
  - Paragraph of text
- **1 MB?**
  - 4 Mega pixel JPEG (compressed) image
- **1GB?**
  - One hour of SD TV or 7 minutes of HDTV
- **1TB?**
  - 2,000 hours of audio (uncompressed), 17,000 hours of MP3s
- **1PB?**
  - Enough data to store the DNA of the entire population of the US – three times!



## The "biggest" data?

**What do you think is the biggest data overall?**

a) Text
b) Images
c) DNA
d) Videos
e) Census Data




## BIGDATA

- **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 *biggest* data!

## 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




## Techniques that Help: Compression

- **Entropy compression reduces data volume by removing redundant information**
- **This compression is reversible but has mathematically proven limits.**
- **Example:**

  **AAAAAABBBBBCCC -> 6A5B3C**

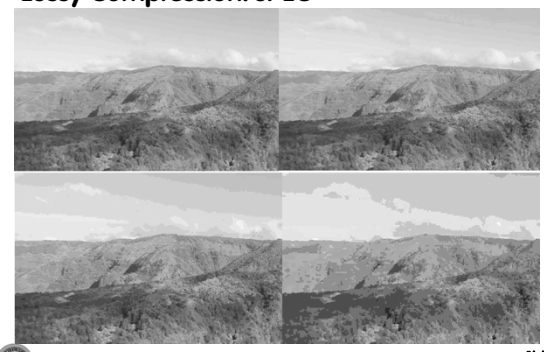



## Techniques that Help: Compression

- **Lossy compression reduces data volume by removing irrelevant information**
- **This compression is not fully reversible but only has perceptual limits.**
- **Compression needs an agreement on decompression = "format"**



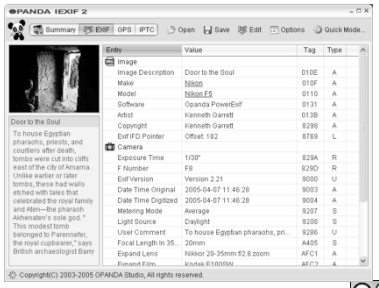

## Lossy Compression: JPEG






## Techniques that help: Metadata

- **Metadata: Data about data. Helps processing of data, e.g. search**
- **Example:**

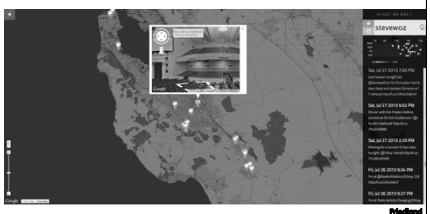






## Two Main Reason for Digital Data

- **Digital data can be copied without loss.**
- **Digital data can be processed by a computer, e.g. for search**
- **Problems:**
  - Privacy
  - Security



## One Main Reason for Big 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?
- **But privacy is a challenge: Future Lecture**

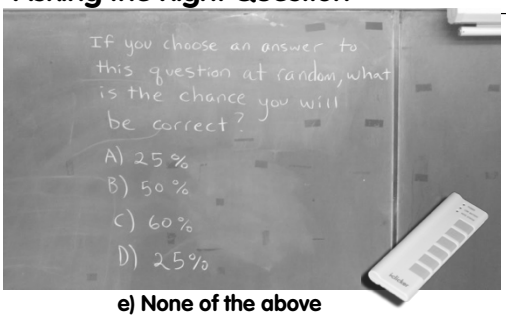



## Is Data the Solution to Everything?

- **Careful: Correlation does not imply causation**
- **"Even" Internet data is biased**
- **It's easy to draw conclusions too quickly**
- **The right questions need to be answered using proper data**




## Asking the Right Question




**e) None of the above**

http://flowingdata.com/2011/10/28/best-statistics-question-ever/




## 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.**