CSCE990 Data Visualization

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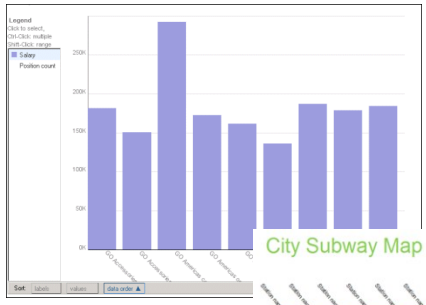
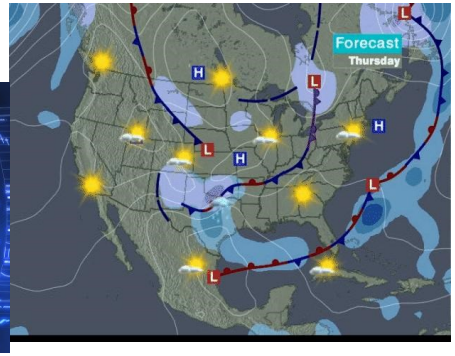
What is visualization?

- **Communication** of **information** using **graphical** representations



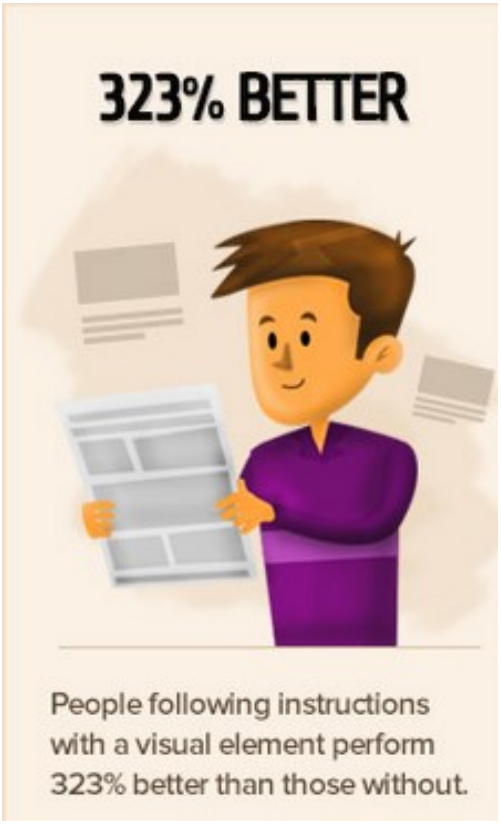
- Everyday and everywhere
  - Bar chart in a newspaper
  - Subway map
  - Weather chart
  - Stock market analysis
  - ….

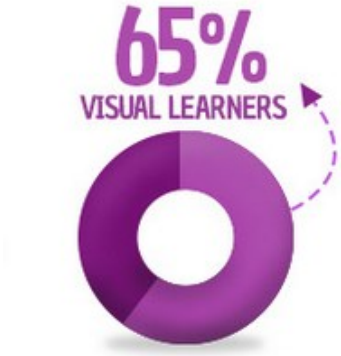


Why visualization?

- Pictures have been used for communication since before the formalization of written language

- Our brain is well built for processing pictures
  - **Speed**
    - Image interpretation is performed in parallel
    - Text analysis is limited by sequential process of reading
    - One biological study estimates the transmission speed of the optic nerve at around 9Mb/sec
  - **Pattern matching**
    - Our visual system can quickly identify important patterns from massive data
      - E.g. face recognition from a large number of people





http://www.quicksprout.co
visualization/?display=wide

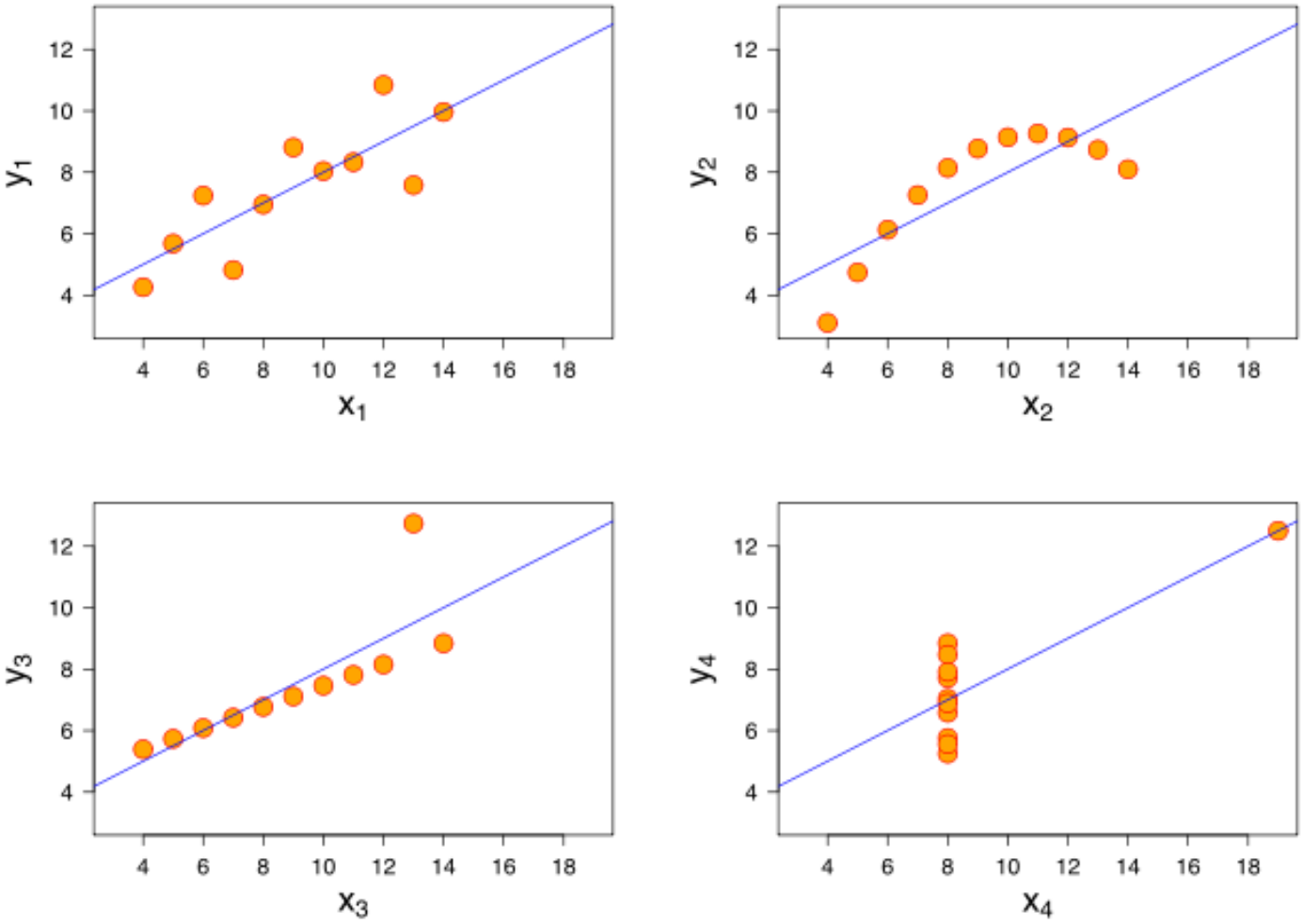
A classic example

- Four data sets
  - Each containing a set of data points in (x, y)

Property	Value
Mean of x in each case	9 (exact)
Variance of x in each case	11 (exact)
Mean of y in each case	7.50 (to 2 decimal places)
Variance of y in each case	4.122 or 4.127 (to 3 decimal places)
Correlation between x and y in each case	0.816 (to 3 decimal places)
Linear regression line in each case	$y = 3.00 + 0.500x$ (to 2 and 3 decimal places, respectively)

  - **No much of interest in a spreadsheet**

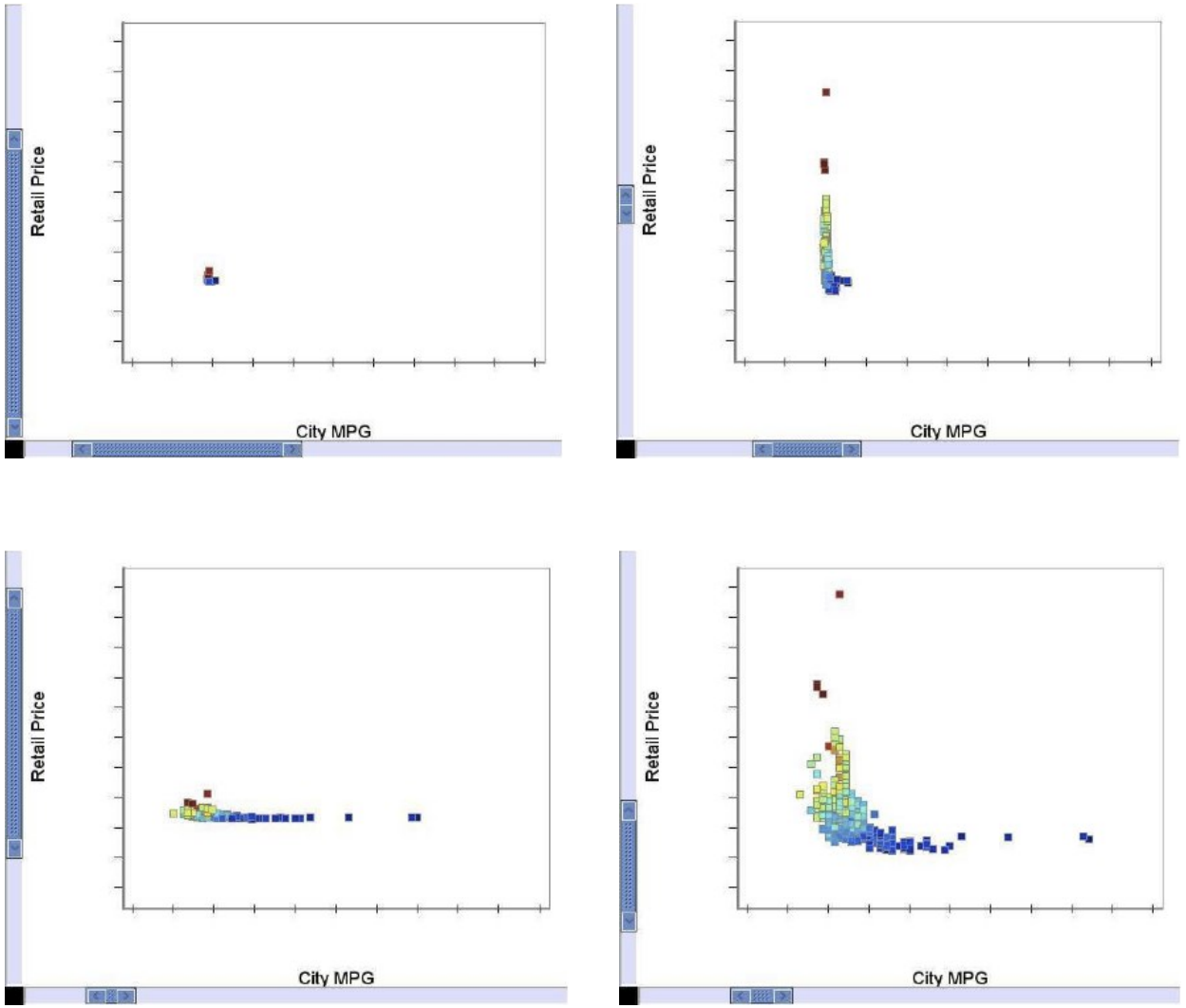
Magic!



Why is visualization challenging?

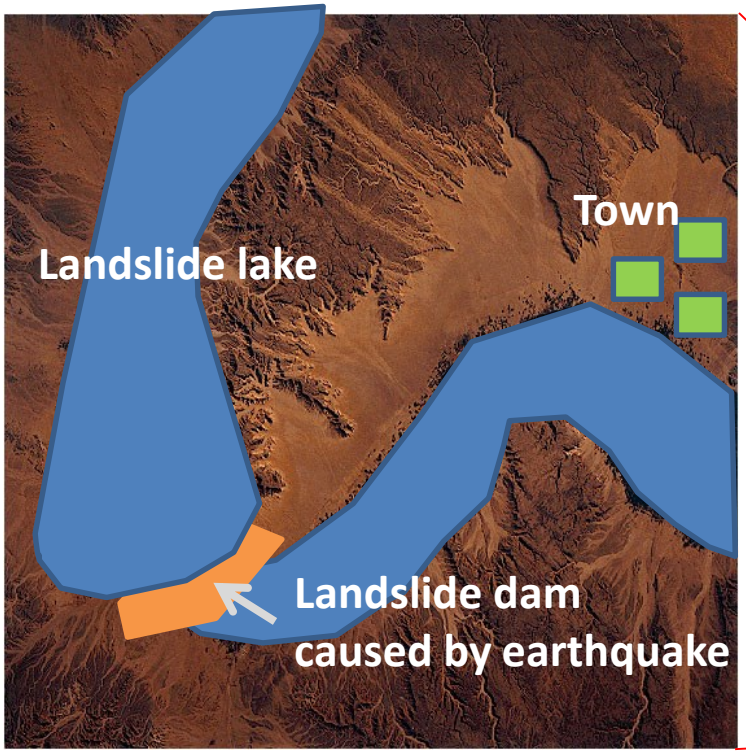
Why is visualization challenging?

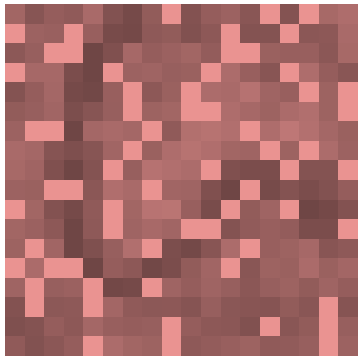
The same data plotted with different scales is perceived dramatically differently.



Why is visualization challenging?

- Big data – **dilemma**
  - Example: **landslide lake**



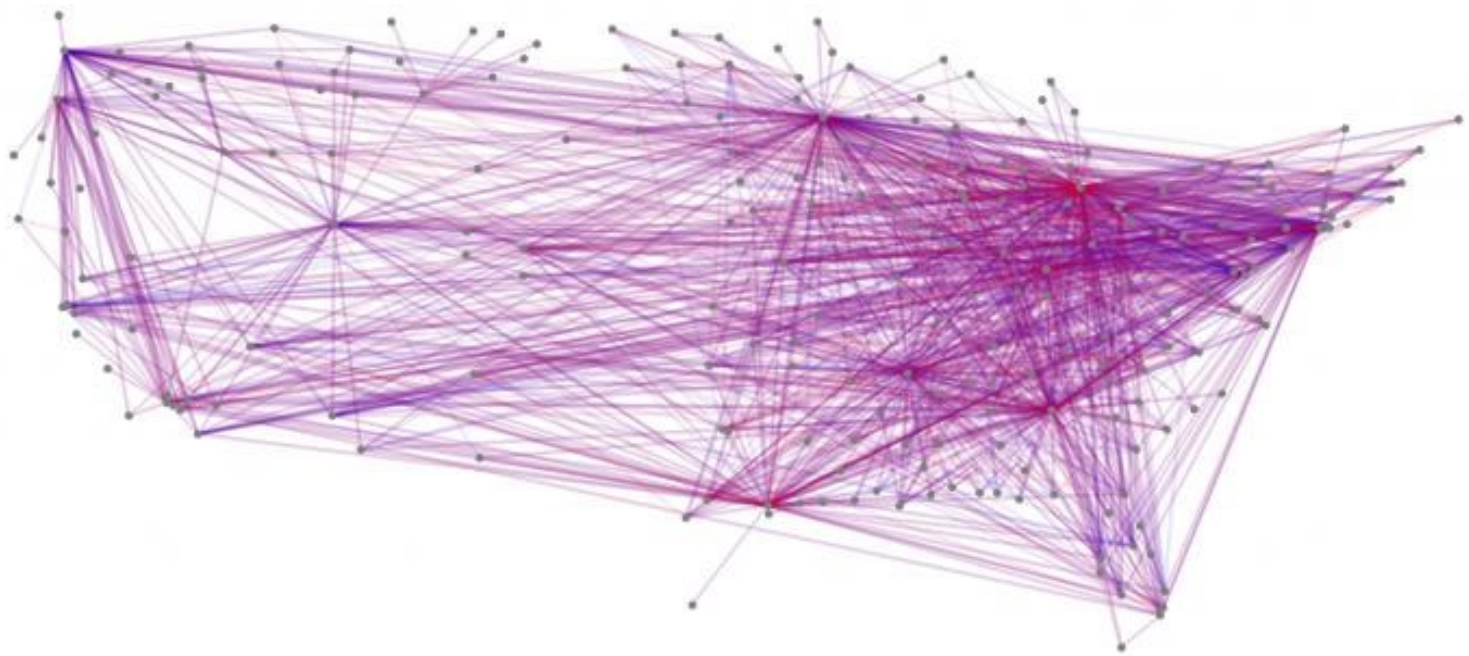


Coarser resolution:
missing details

Finer resolution:
Finding the needle in a haystack

Why is visualization challenging?

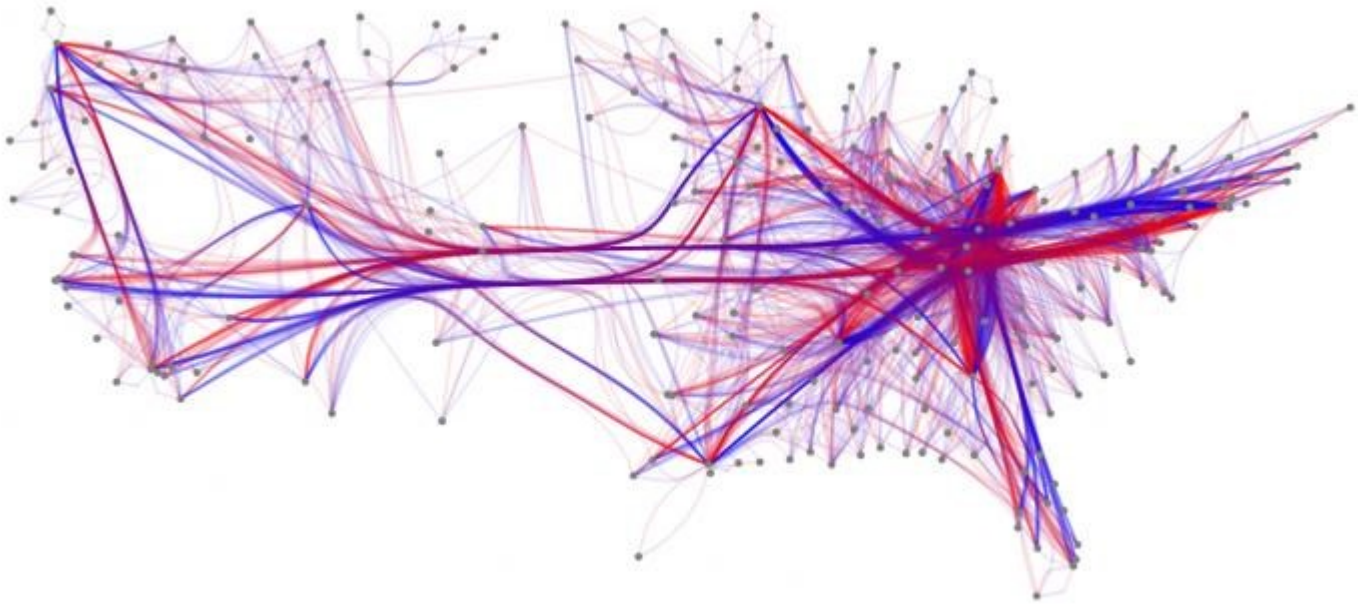
- Big data – **dilemma**
  - Example: network



Kitware. An implementation of the paper, “Divided Edge Bundling for Directional Network Data”, by David Selassie, Brandon Heller and Jeffrey Heer. IEEE InfoVis 2011.

Why is visualization challenging?

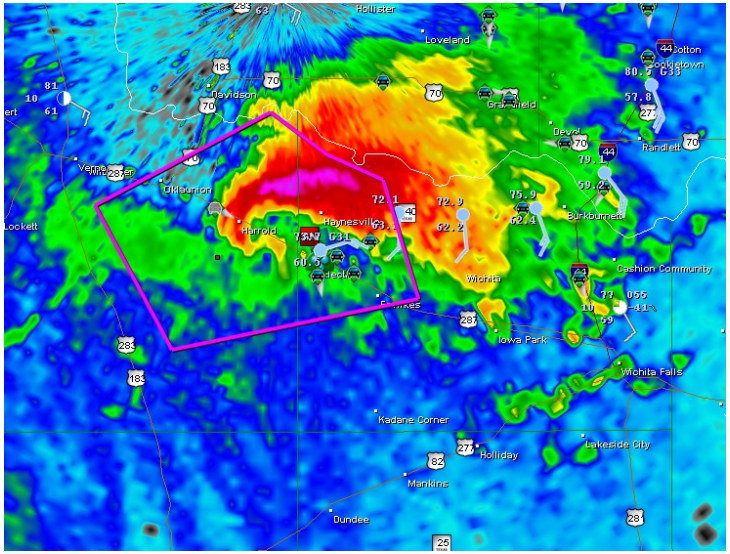
- Big data – **dilemma**
  - Example: network



Kitware. An implementation of the paper, “Divided Edge Bundling for Directional Network Data”, by David Selassie, Brandon Heller and Jeffrey Heer. IEEE InfoVis 2011.

More important benefits

- Visualization in big data era
  - Allows us access to **huge amounts of data** in ways that would not be otherwise possible
  - Gives us access to the knowledge **quickly**, **efficiently**, and **effectively**, and obtain insights
    - Weather radar data
      - Hundreds of radars
      - GB data per minutes
    - Geographic information
    - Social network
    - … …



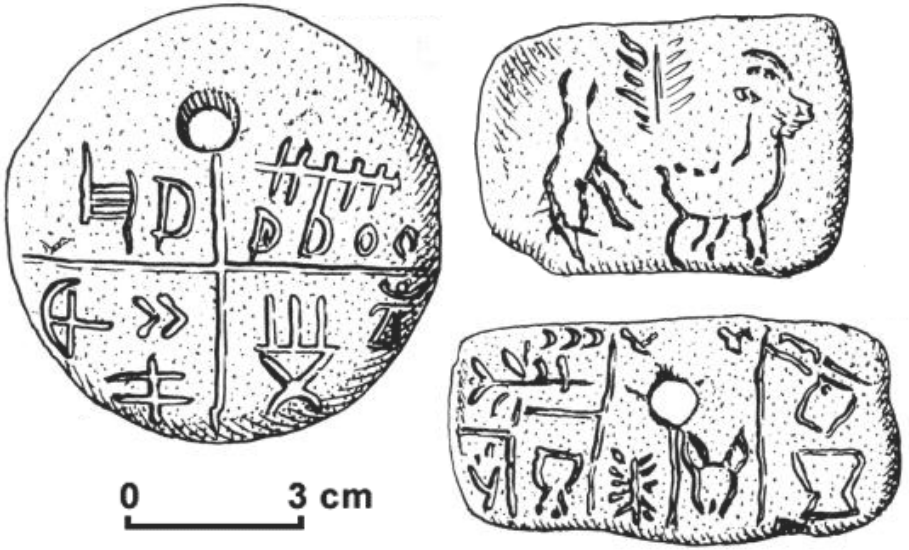
Early Visualization

- Perhaps the first technique for **graphically** recording and presenting **information**

Cave paintings by early man approximately **30,000** years ago

Early Visualization

- Early graphical writing



Tartaria Tablets, **5500BC**

Kish Tablet, **3500 BC**

Early Visualization

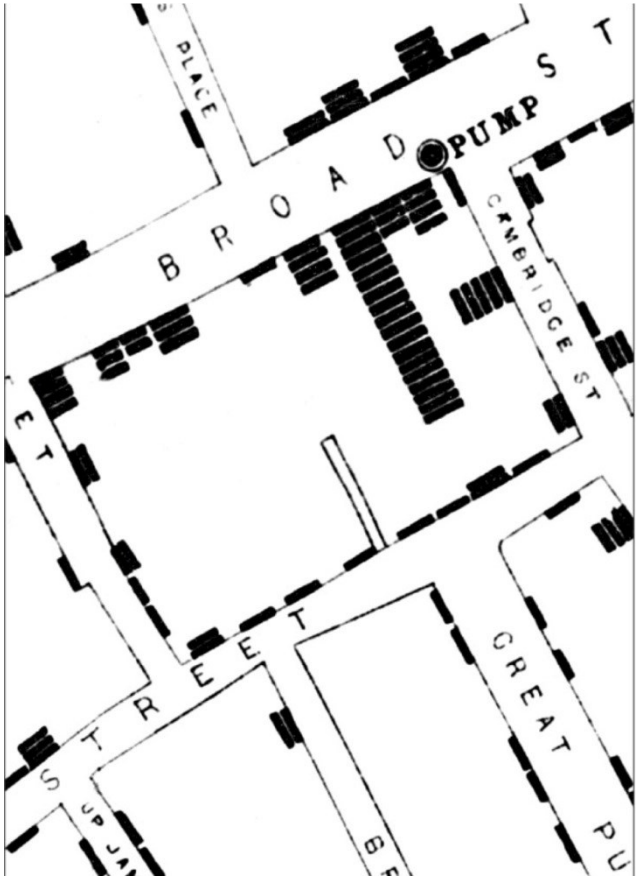
- Some necessary need for survival

Peutinger map: the road network in the Roman Empire.
Created in **15th century** based on a **4th-century map**

Early Visualization

The Lord of the Rings, 20th century

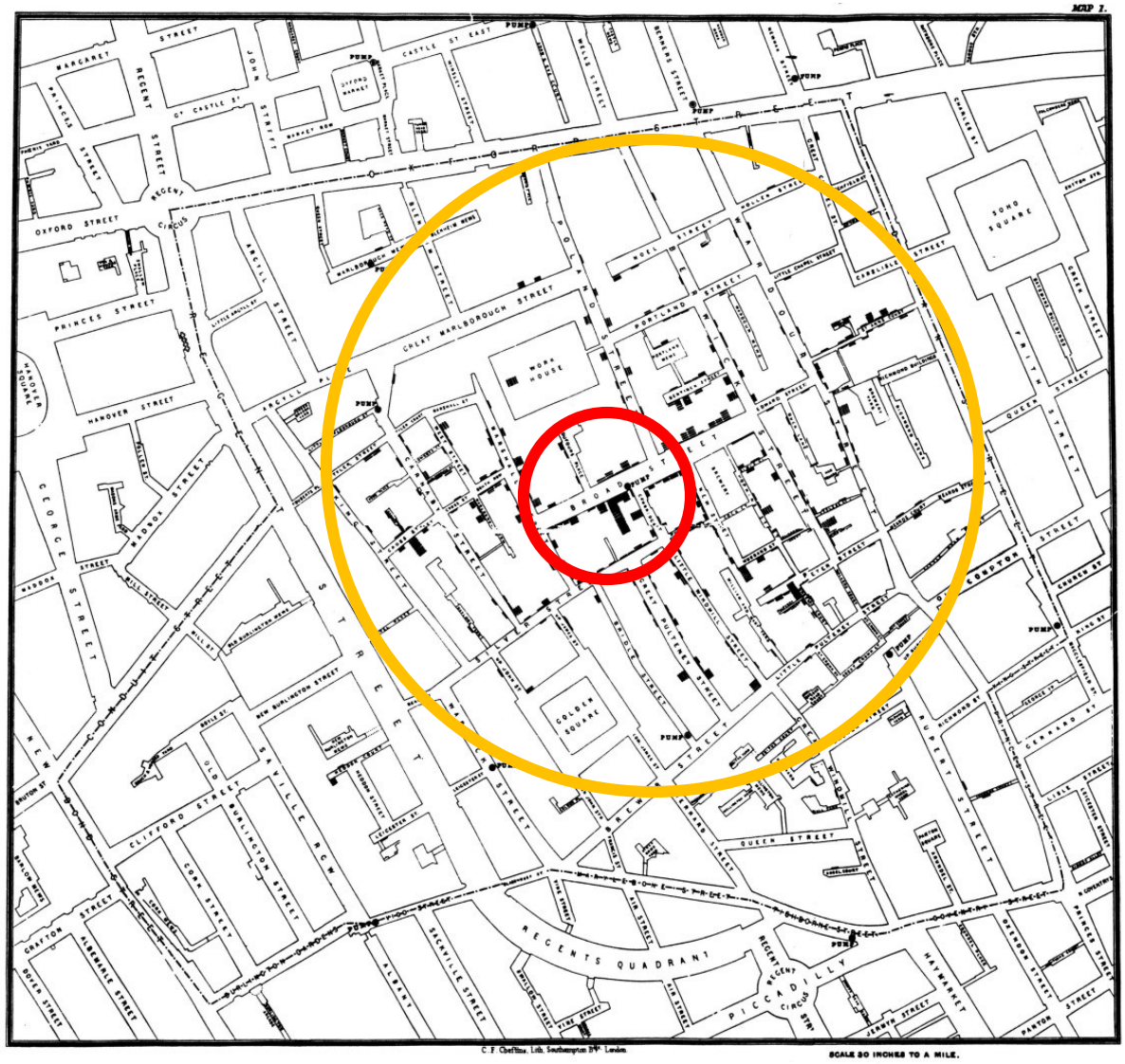
Early Visualization



A section of John Snow's map of the deaths from cholera in London in 1663.

Each bar within the houses represents one deceased individual.

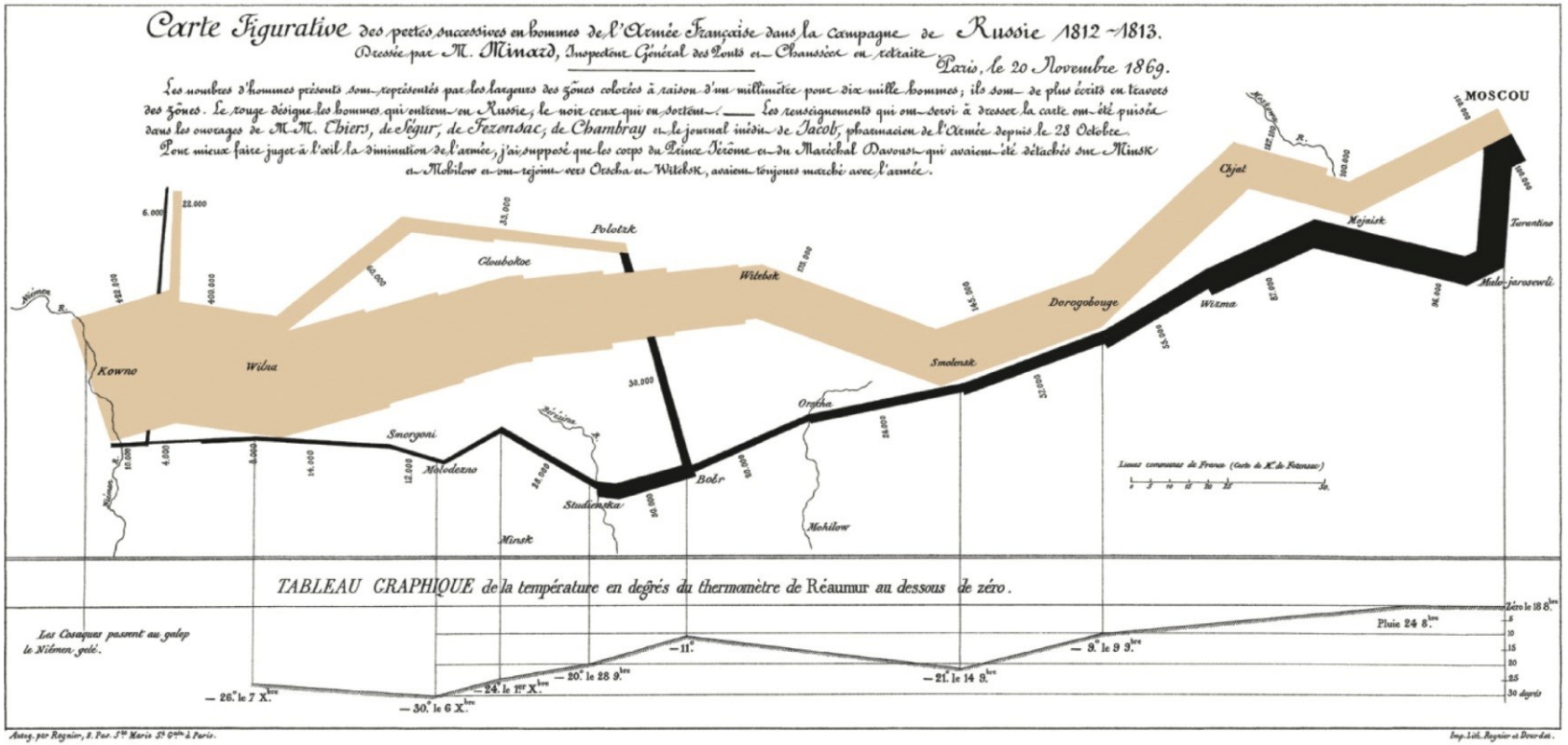
Early Visualization



Overview map of the deaths from cholera in London in 1663.

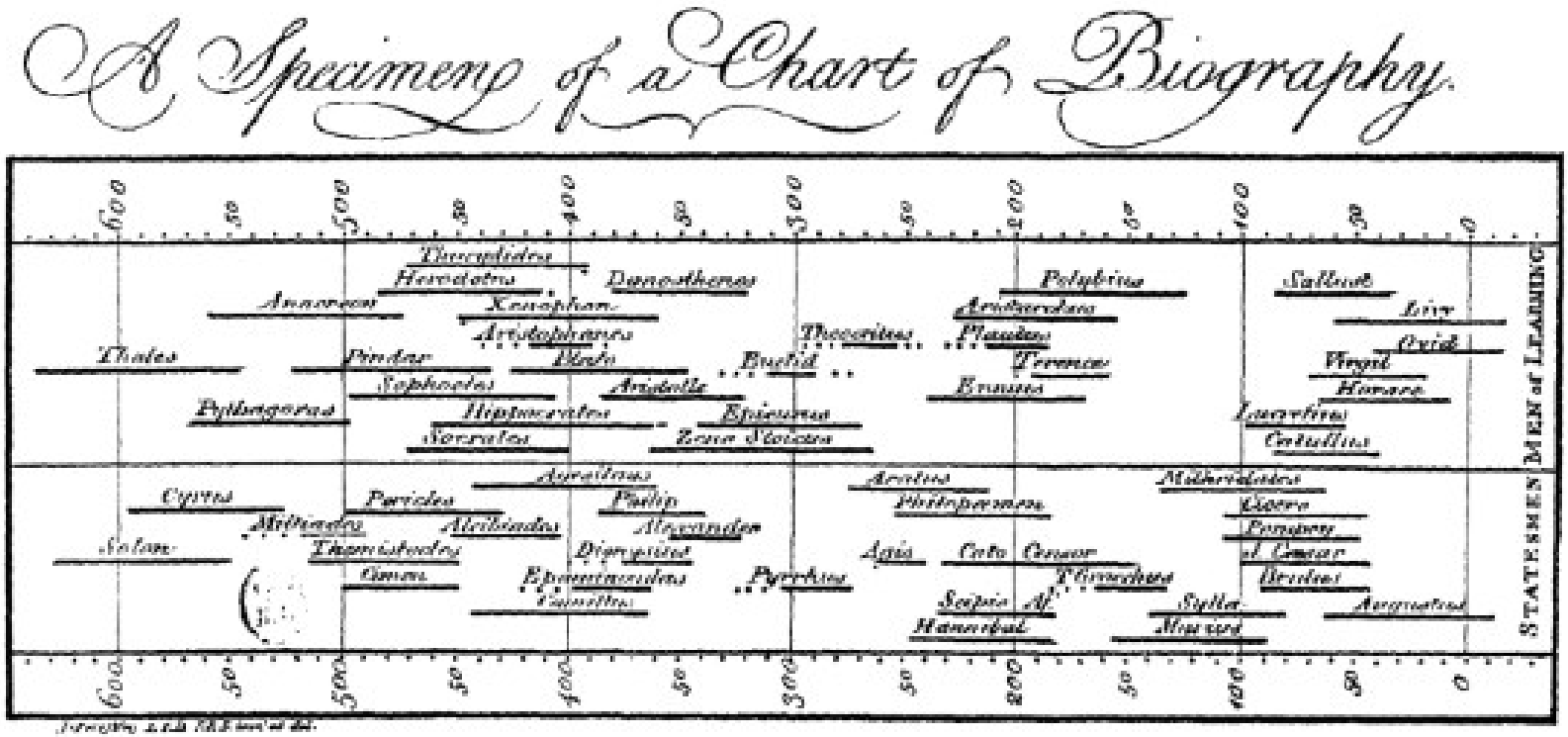
Note the concentration around the Broad Street Water Pump. Note as well the outliers.

Early Visualization



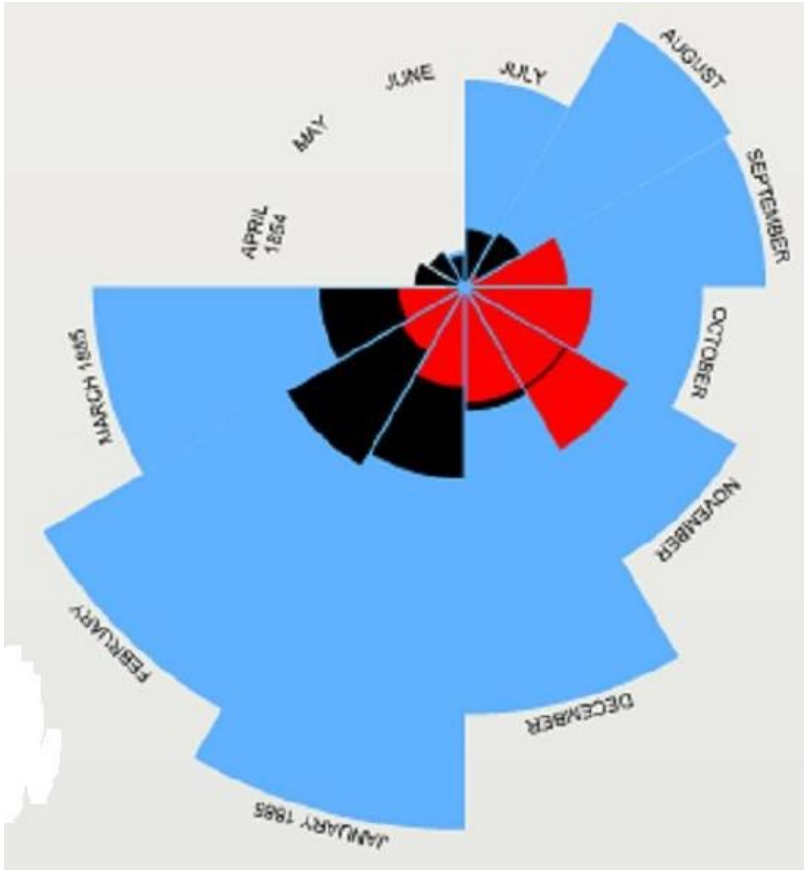
Minard's map, showing Napoleon's march on Moscow. The width of the line conveys the size of the army at that location. Color indicates the direction of movement. The temperature is plotted at different points along the retreat at the bottom. (1869)

Early Visualization



Joseph Priestley's display of the longevity of famous people (1765).

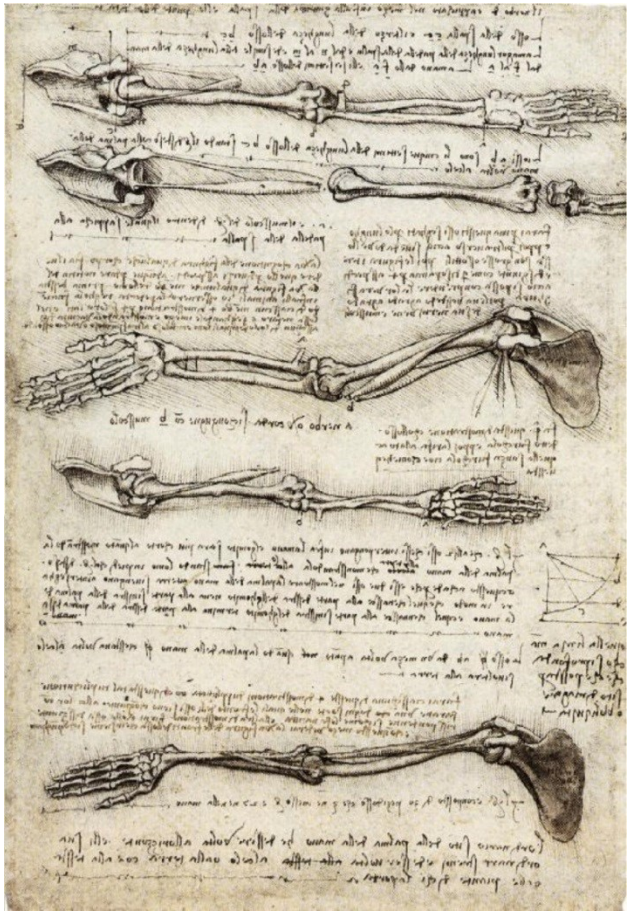
Early Visualization



Florence Nightingale's coxcomb chart showing monthly deaths from battle and other causes (1858).

Blue represents the deaths from disease, red represents deaths from wounds, and black represents all other deaths.

Early Visualization



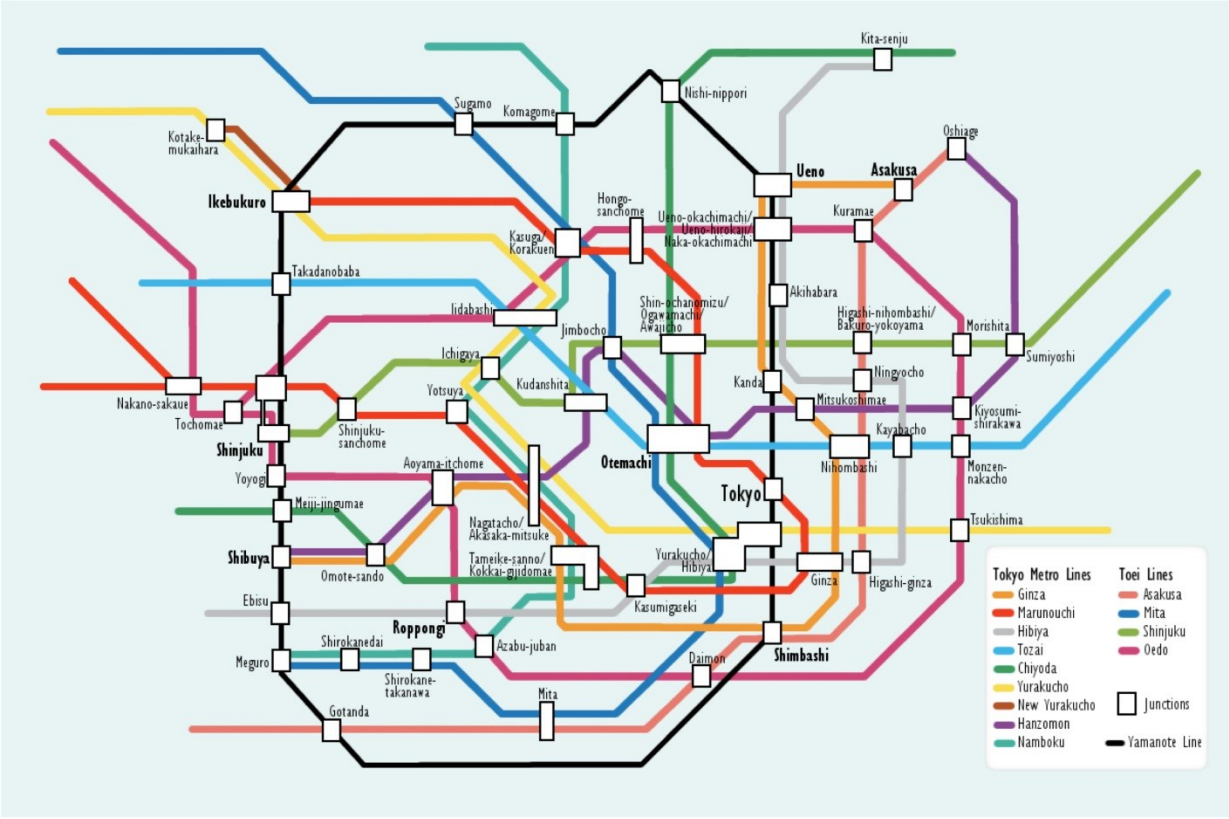
Leonardo Da Vinci's study of the motion of the human arm (1510).

Early Visualization

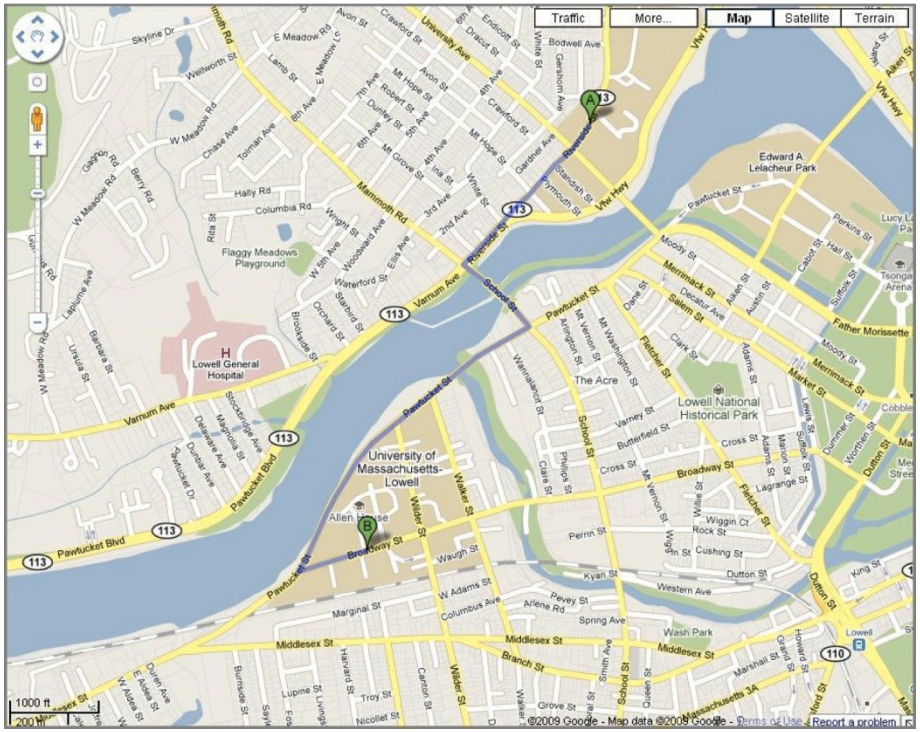
Leonardo Da Vinci's picture of water flow

Visualization Today

The Tokyo Underground map. A logical representation of the metro highlighting **qualitative** relationships between the stops.



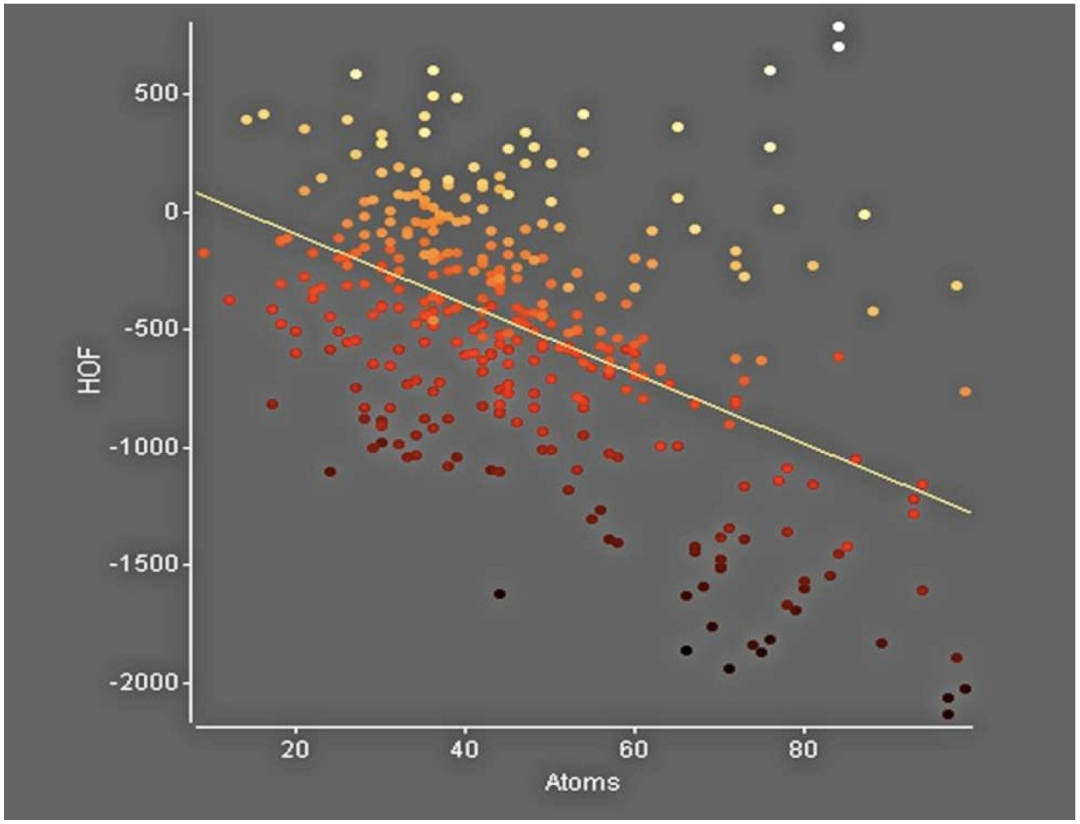
Visualization Today



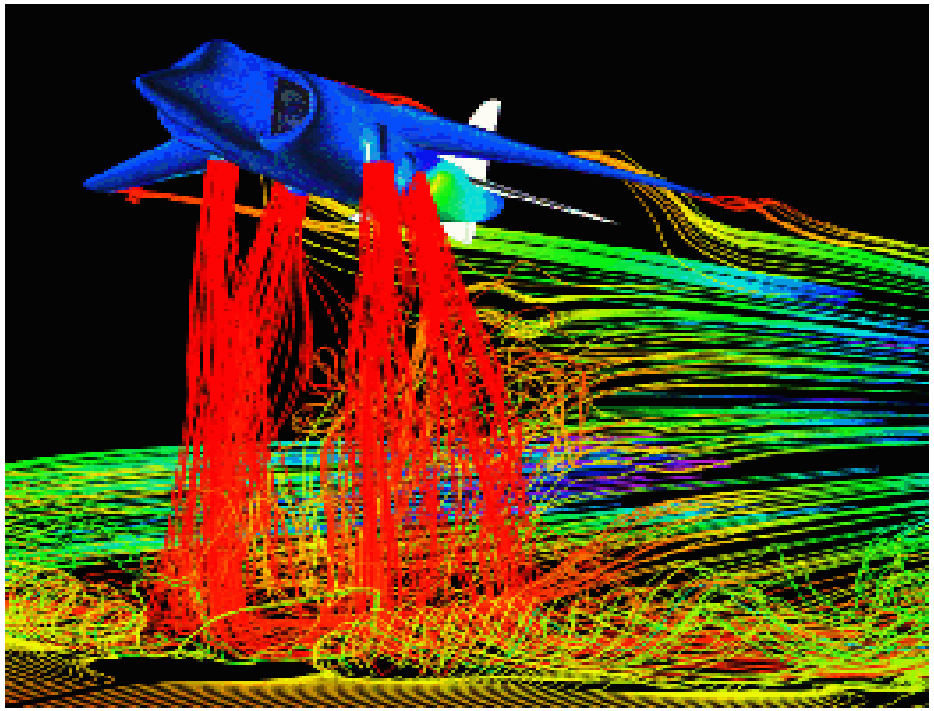
The google.com map directions from 198 Riverside St., Lowell, MA (UMass Lowell, North Campus) to 883 Broadway St., Lowell, MA (UMass Lowell, South Campus). Google.com maps provide graphical cues drawn on top of road maps to indicate driving directions from point A to point B.

Visualization Today

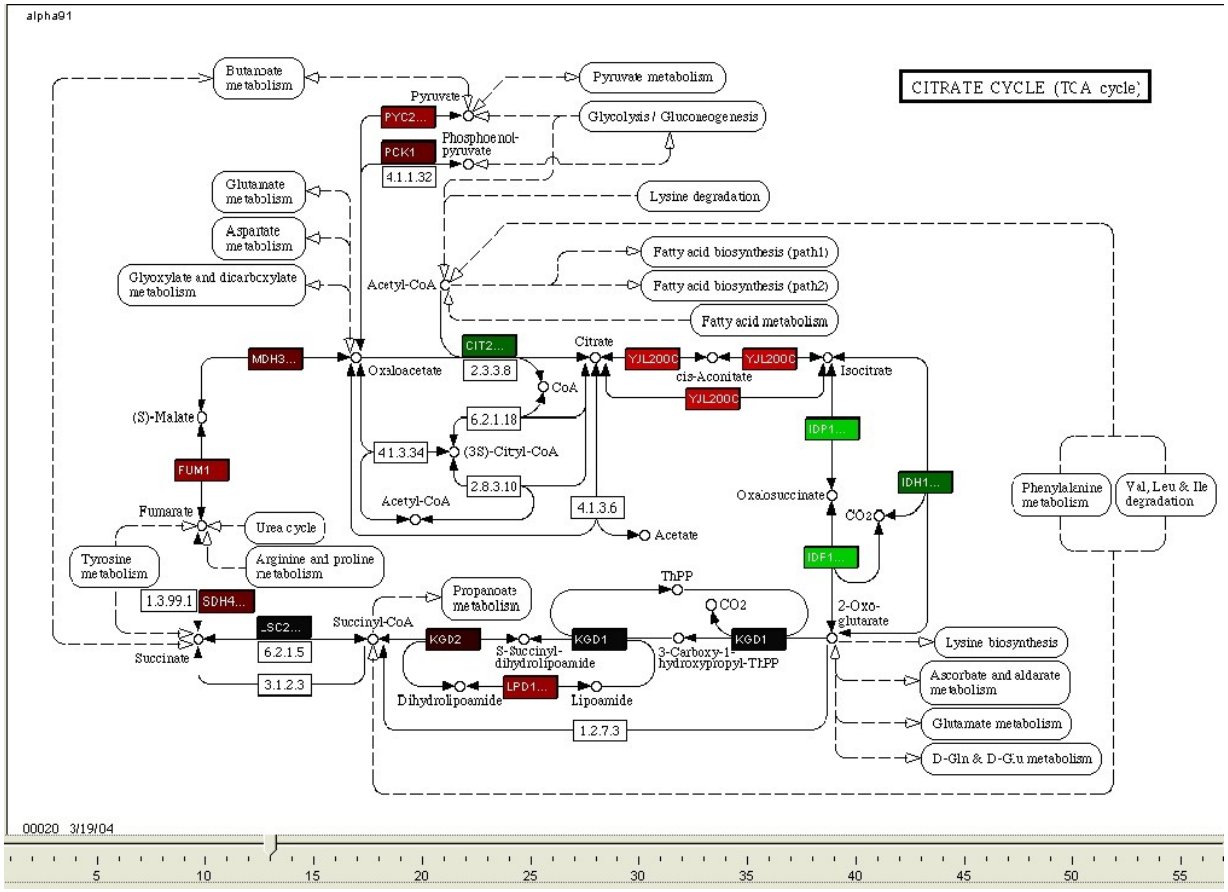
Yeast mechanism of action data with regression line.



Visualization Today



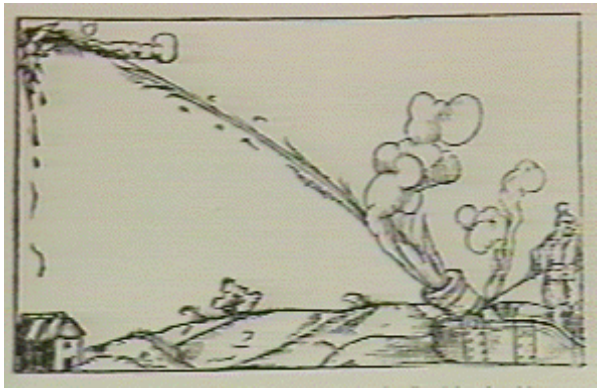
Visualization Today

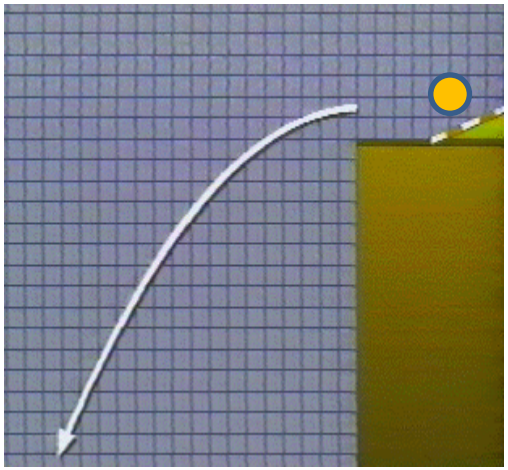


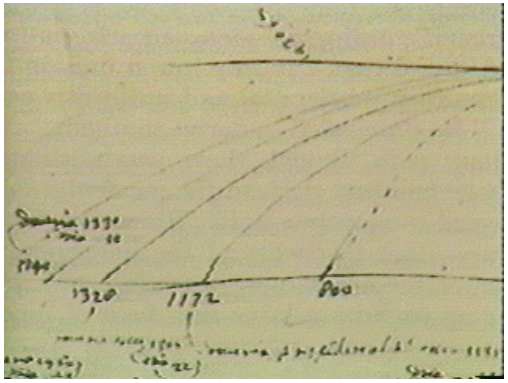
A pathway represented by a network with nodes representing genes and color the level of expression.

Why is visualization a necessity?

- Galileo's Analysis of Projectile Motion







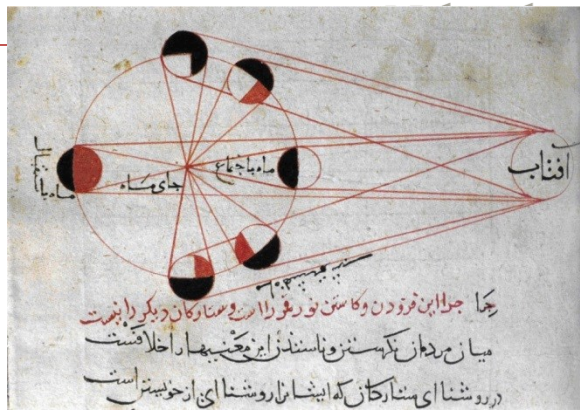
Parabola

$$y = ax^2 + bx + c$$

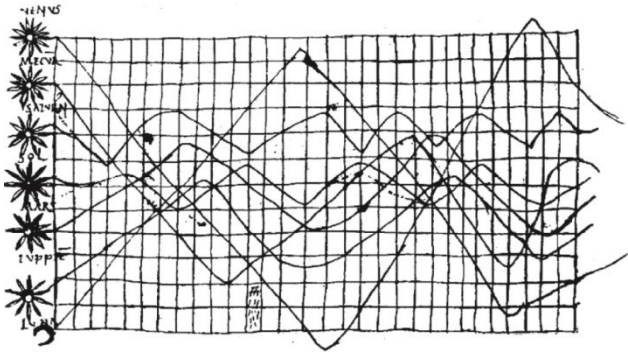
http://www.mcm.edu/academic/galileo/ars/arshtml/mathofmotion2.html

Why is visualization a necessity?

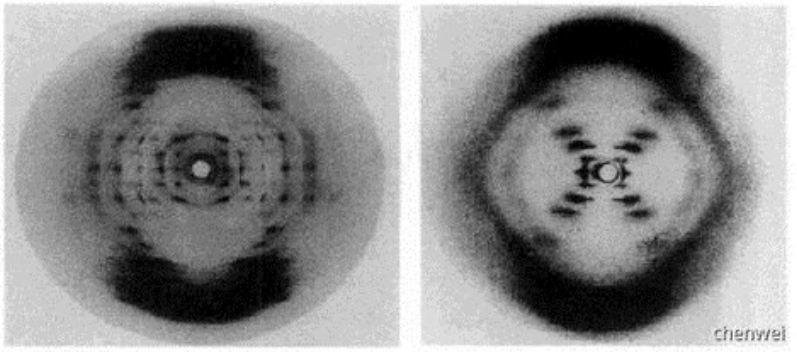
- Many many examples
  - Kepler's laws
  - Newton's laws
  - DNA structure
  - … …
  - Numerous scientific publications



Produced by Biruni circa 1030. Shows the phases of the moon in orbit.



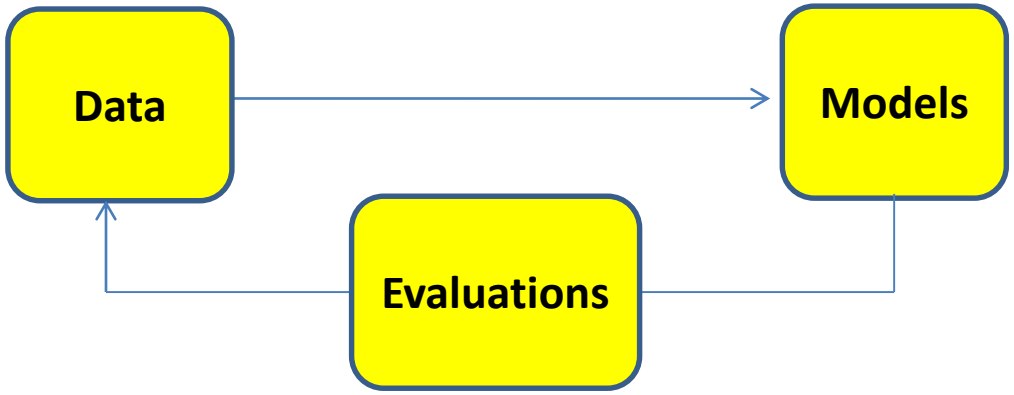
Planetary motion.



The x-ray diffraction image

Why is visualization a necessity?

- Human's Knowledge Discovery Pipeline



- Visualization
  - Can be used at every step of the KD pipeline
  - Often a part of this larger process
  - Tightly coupled with analysis

Visualization vs. Computer Graphics

- Computer Graphics
  - Graphical objects and organization of graphic primitives
- Visualization
  - More than simply computer graphics
  - Based on the underlying data (spatial positions, populations, or physical measures)
  - Include aspects from numerous other disciplines
    - Human-computer interaction
    - Psychology for human perception
    - Databases
    - Statistics
    - Data mining
    - …

Visualization vs. Computer Graphics

- Computer Graphics
  - Creation of images and animations for visual realism
  - Video games, cartoons, advertisements, and movie special effects

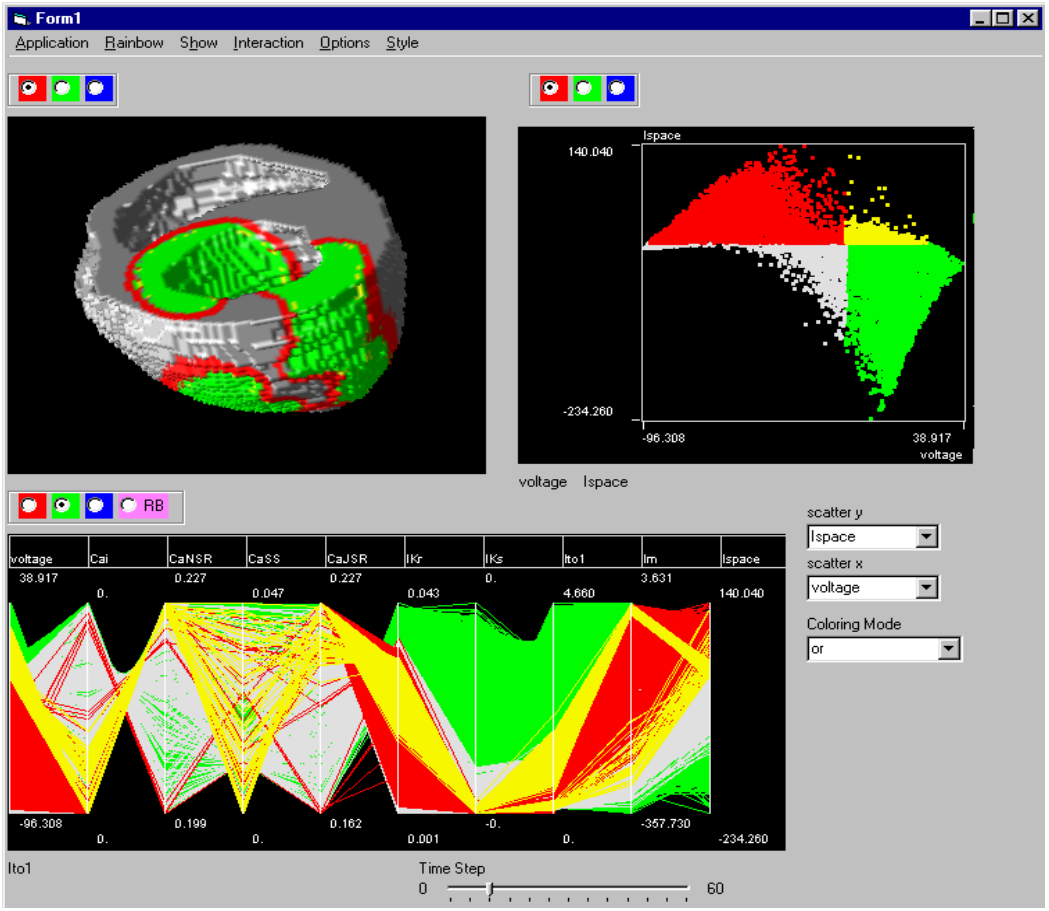
- Visualization
  - Not emphasize visual realism, but effective communication of information
  - Many applications do not deal with physical objects

Visualization vs. Computer Graphics

- Computer Graphics provides tools for visualization
  - Graphics-programming language
    - OpenGL, DirectX, Processing, Java3D
  - Underlying graphics Hardware
    - Intel, Nvidia or AMD graphics cards
  - Rendering process
    - Different shading
  - Output format
    - JPEG, TIFF, AVI, MPEG

Visualization vs. Computer Graphics

WEAVE—A system for visually linking 3D and statistical visualizations (2000)



Visualization vs. Computer Graphics

- Paper keywords from Computer Graphics Forum

This image itself is a visualization.