CSCI 4502/5502

Data Mining - Summer 2023 - Lecture 3 - June 7

Ravi Starzl, PhD

Getting to Know Your Data

1. Data objects and attribute types
2. Basic statistical description of data
3. Data visualization
4. Measuring data similarity and dissimilarity

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Data Objects and Attributes

- Data set: a set of data objects
  - e.g., students, courses, customers, products
- Data object
  - an entity with certain attributes/features/dimensions/variables
  - e.g., patient_id, name, DOB, address, office visits, lab tests
- Attribute type: nominal, binary, ordinal, numeric

Attribute Types

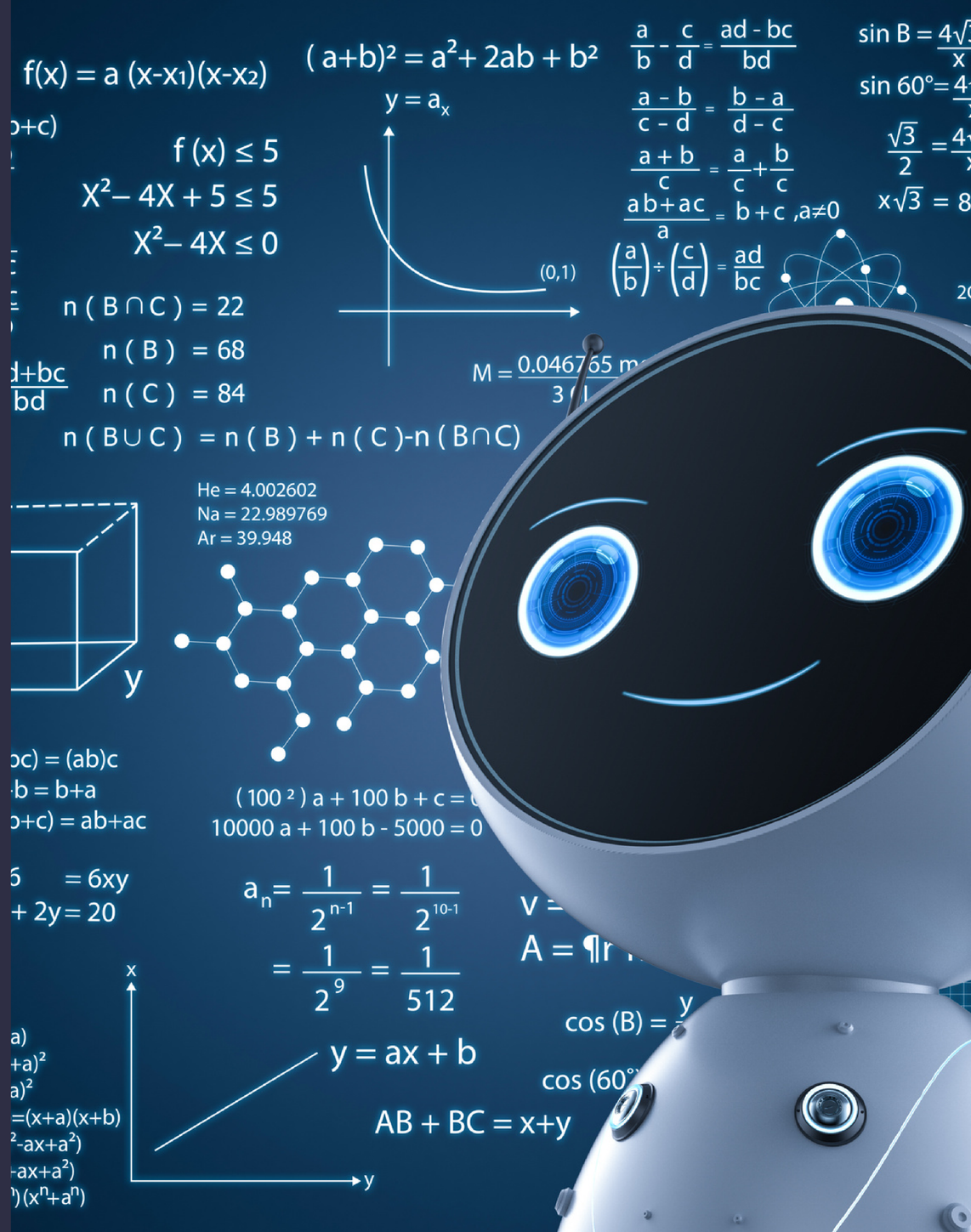
- Nominal (categorical): e.g., major, occupation, city
- Binary (boolean, symmetric or asymmetric)
  - e.g., CS major? professor? Boulder?
- Ordinal: degree, professional rank, vehicle size class
- Numeric (quantitative)

Numeric Attributes

- Interval-scaled
  - e.g., 50 or 100 Fahrenheit degree; Year 2000 or 2020
- Ratio-scaled (true zero-point)
  - e.g., age, dollars, number of books, number of cars
- Discrete vs. continuous
  - discrete: finite or countably infinite; integers vs. real numbers

Statistical Description of Data

- Motivation: better understanding of the data
  - e.g., sales, traffic volume, #likes
- Basics: N, min, max
- Central tendency: mean, median, mode, midrange
- Dispersion: quartiles, interquartile range, variance



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Central Tendency

- Mean

$$\bar{x} = \frac{1}{N}\sum_{i=1}^{N} x_i = \frac{x_1 + x_2 + \cdots + x_N}{N}$$

  - weighted arithmetic mean

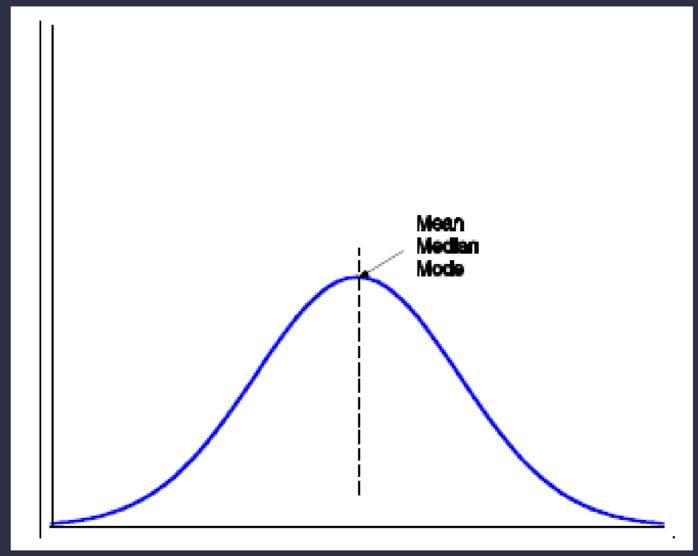
$$\bar{x} = \frac{\sum_{i=1}^{N} w_i x_i}{\sum_{i=1}^{N} w_i} = \frac{w_1 x_1 + w_2 x_2 + \cdots + w_N x_N}{w_1 + w_2 + \cdots + w_N}$$

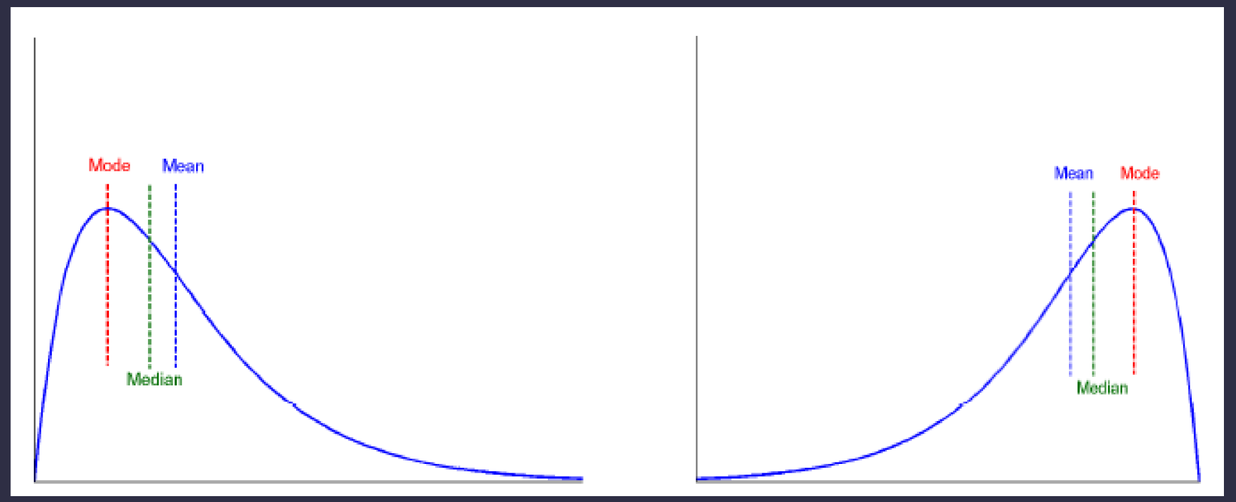
  - trimmed mean: chopping extreme values
- Median
  - middle value if N is odd, otherwise
  - average of the middle two values

$$median = L_1 + \left(\frac{N/2 - (\sum freq)_l}{freq_{median}}\right) width$$

Central Tendency

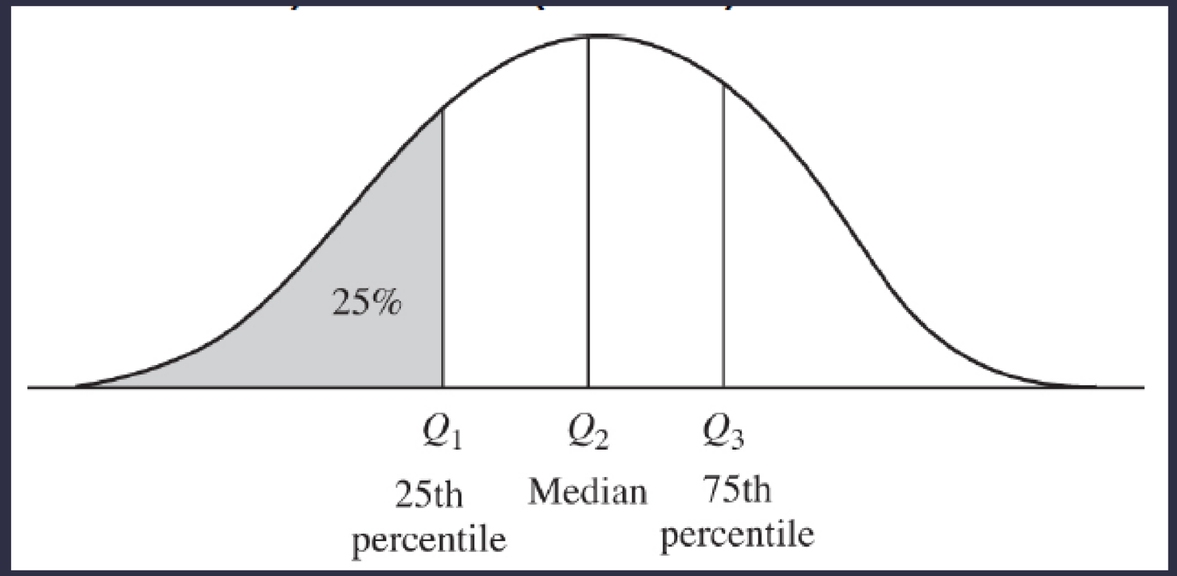
- Mode: value that occurs most frequently
  - unimodal, biomodal, trimodal, multimodal
- Midrange: avg. of min and max

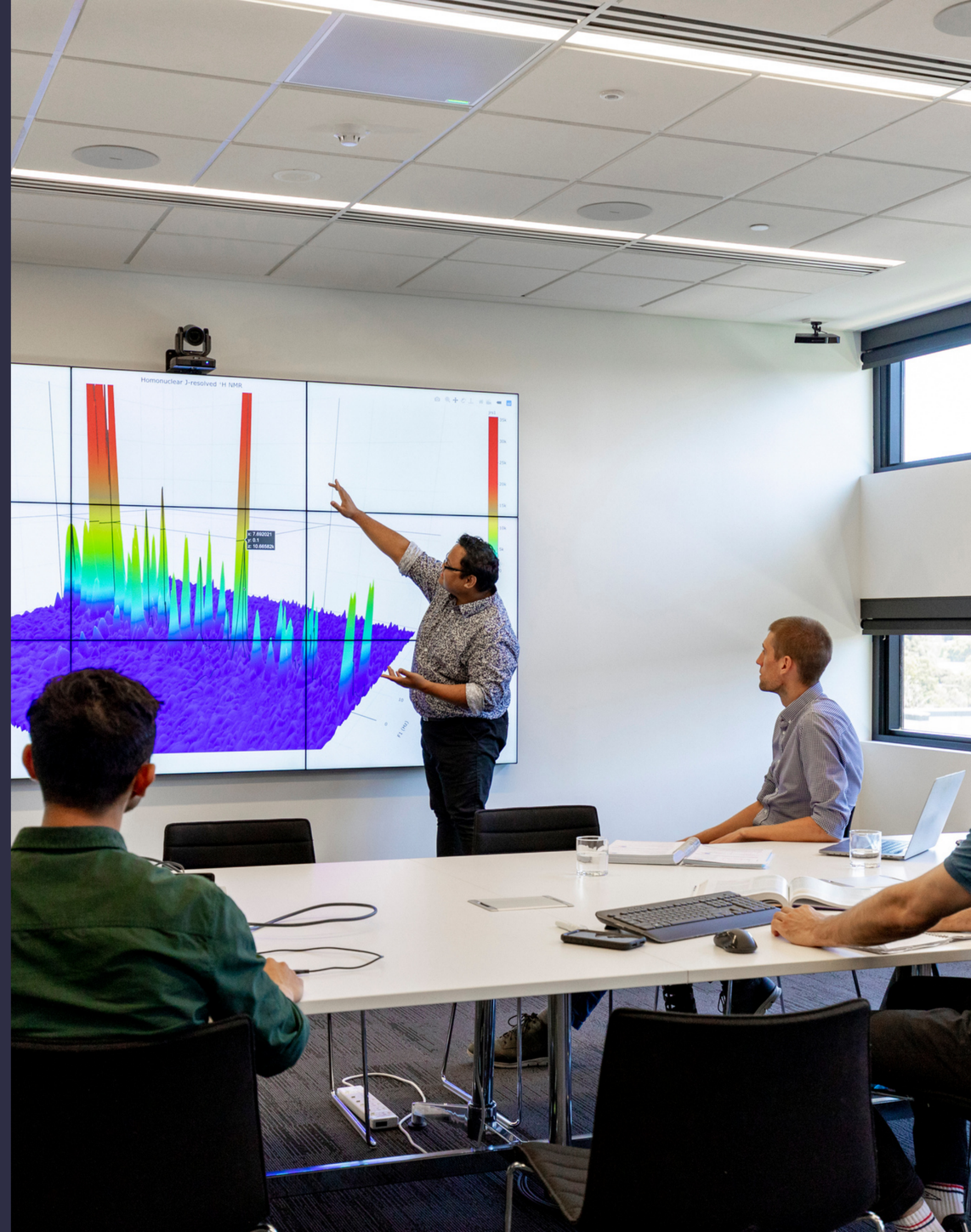




Data Dispersion

- How much numeric data tend to spread
- Range: difference between max and min
- Quartiles: Q1 (25th percentile), Q3 (75th)
- Interquartile range
  - IQR = Q3 - Q1



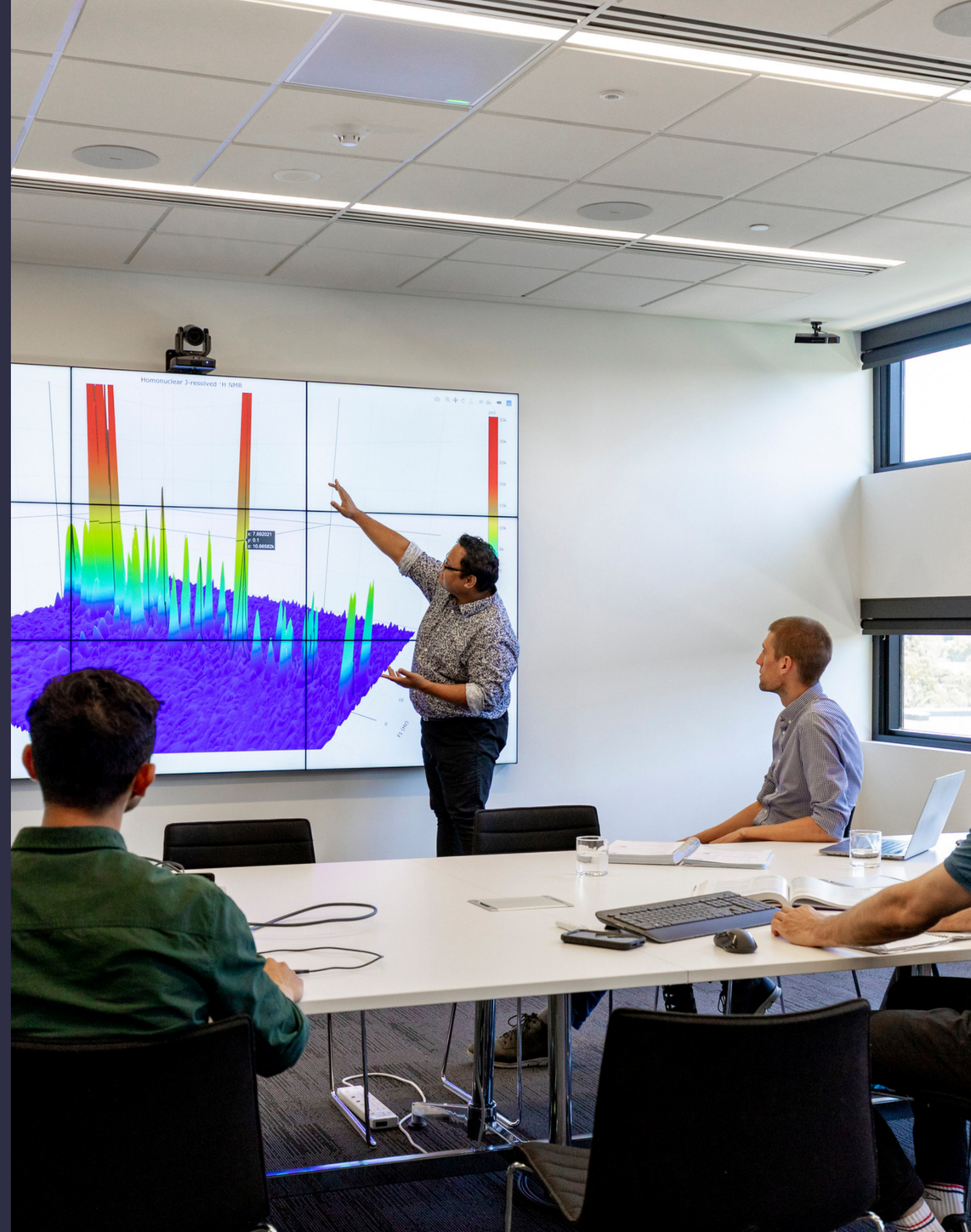


Data Dispersion

- Five number summary: min, Q1, median, Q3, max
- Outlier: value higher/lower than 1.5 x IQR of Q3/Q1
- Variance:

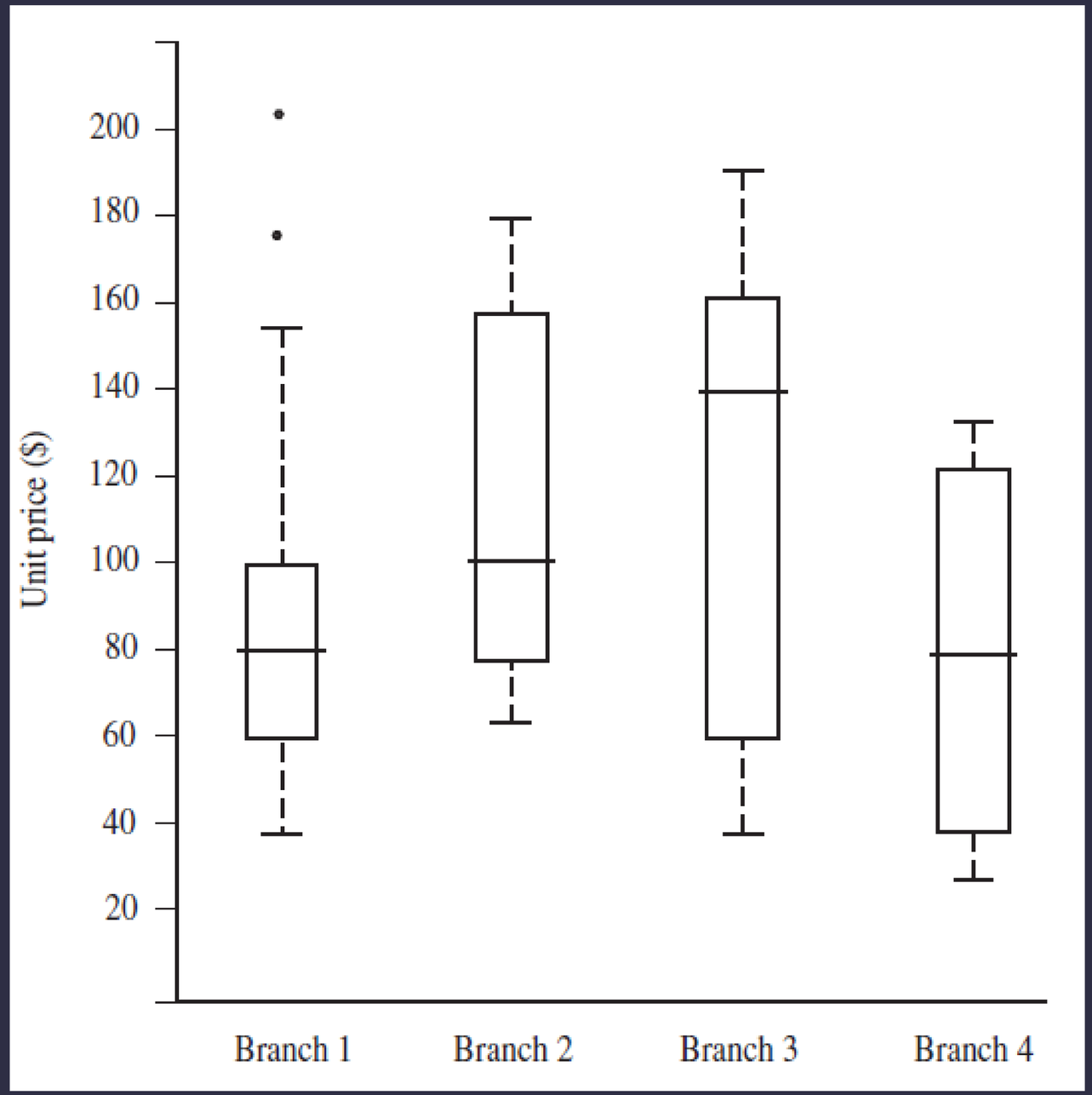
$$\sigma^2 = \frac{1}{N}\sum_{i=1}^{N}(x_i - \bar{x})^2 = \frac{1}{N}\left[\sum x_i^2 - \frac{1}{N}(\sum x_i)^2\right]$$

- Standard deviation: square root of variance



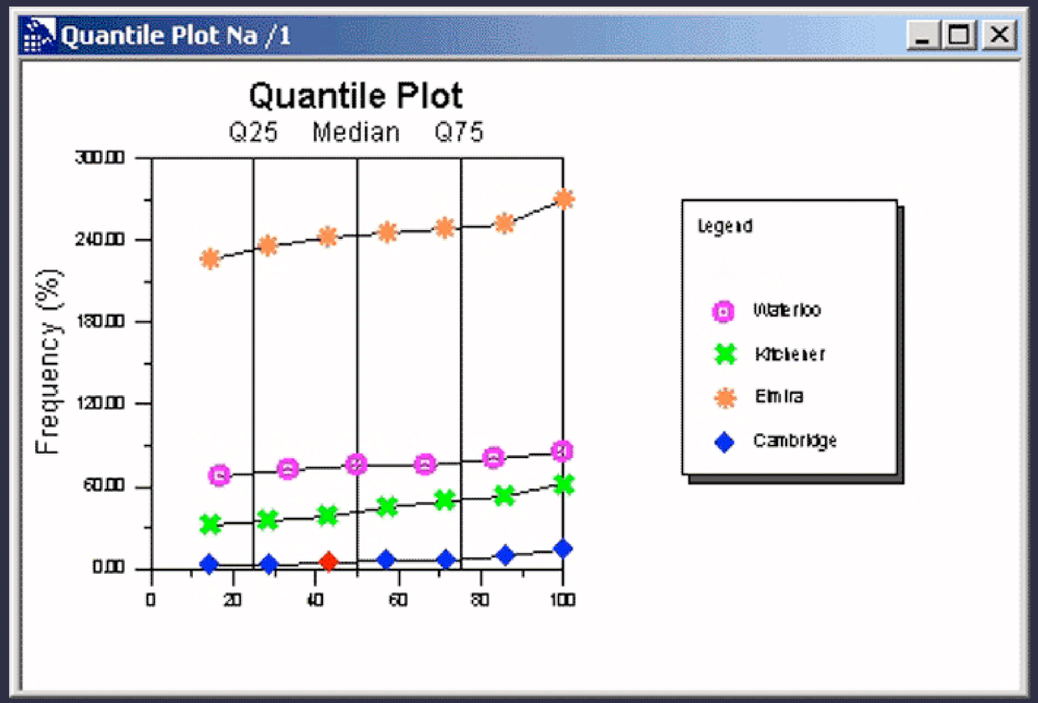
Data Dispersion

- Boxplot
  - box: Q1, M, Q3, IQR
  - whiskers:
    - min, max, 1.5 x IQR
  - outliers



Graphic Displays

- Quantile Plot



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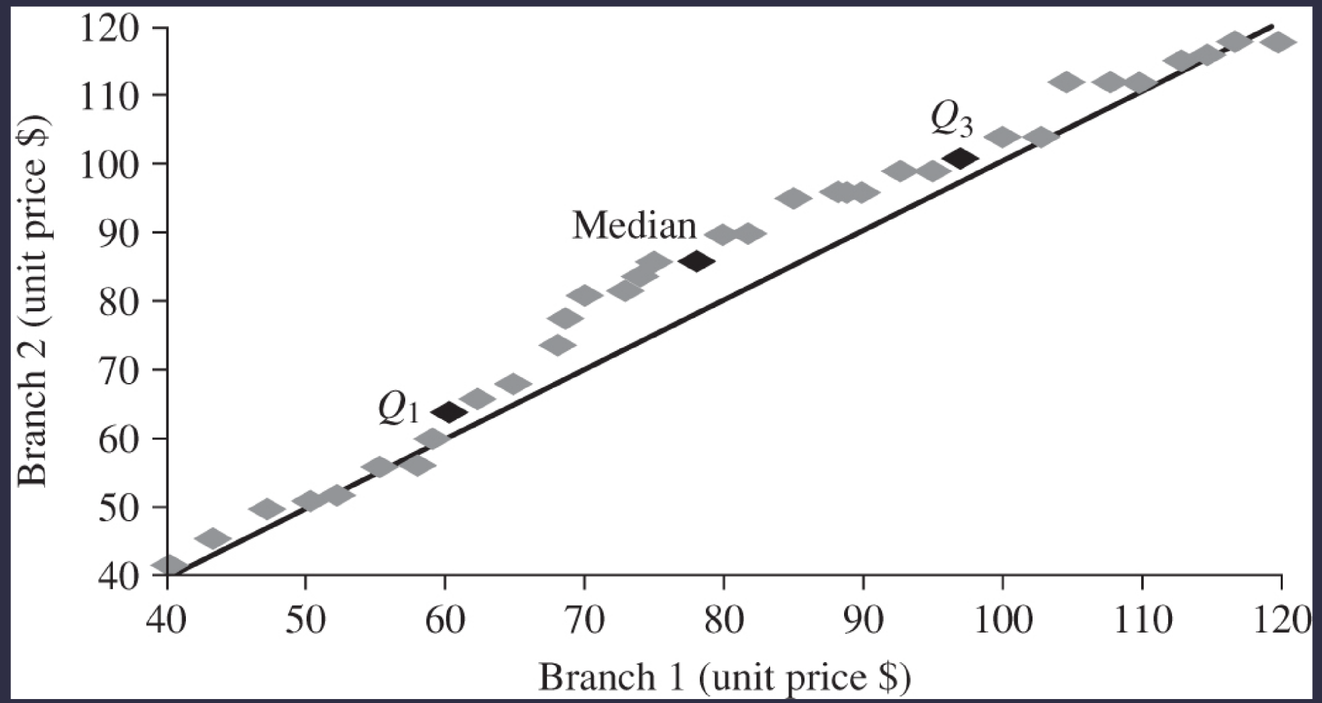
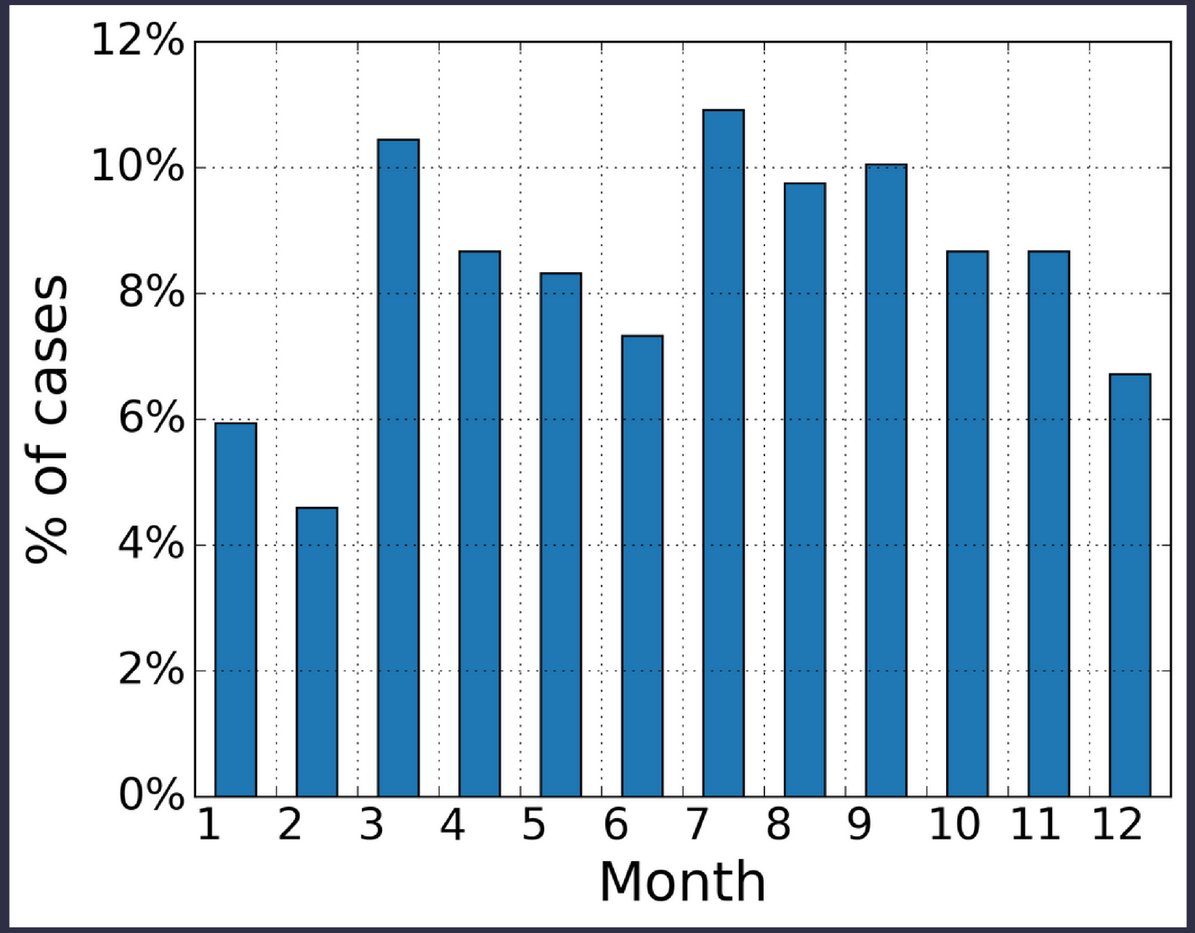
- Quantile-quantile Plot (Q-Q Plot)



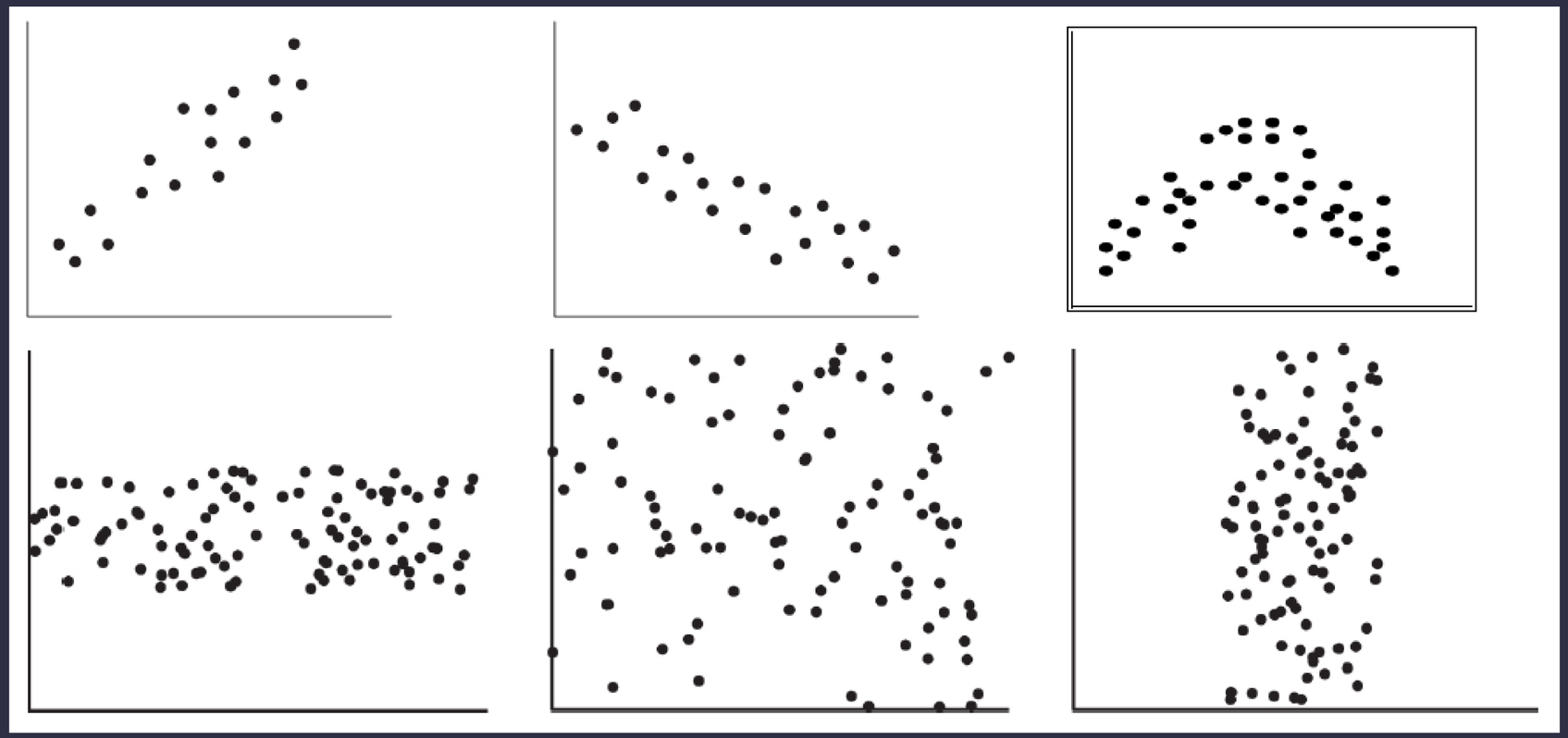
Graphic Displays

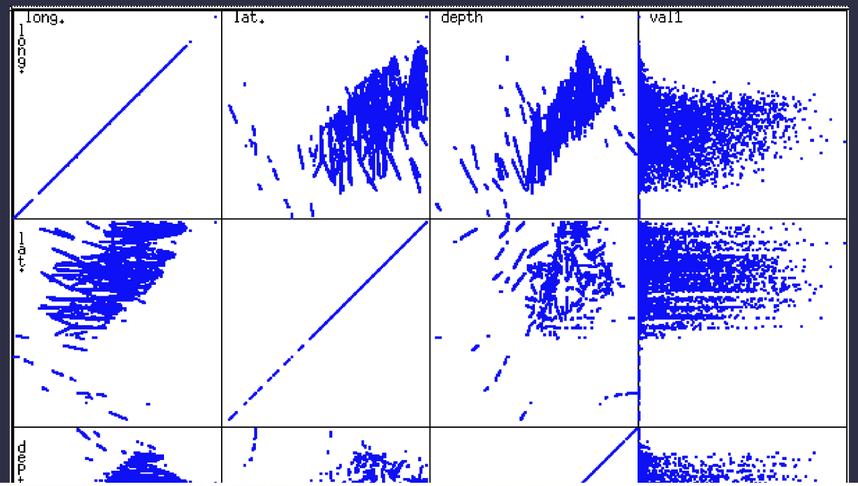
- Histogram

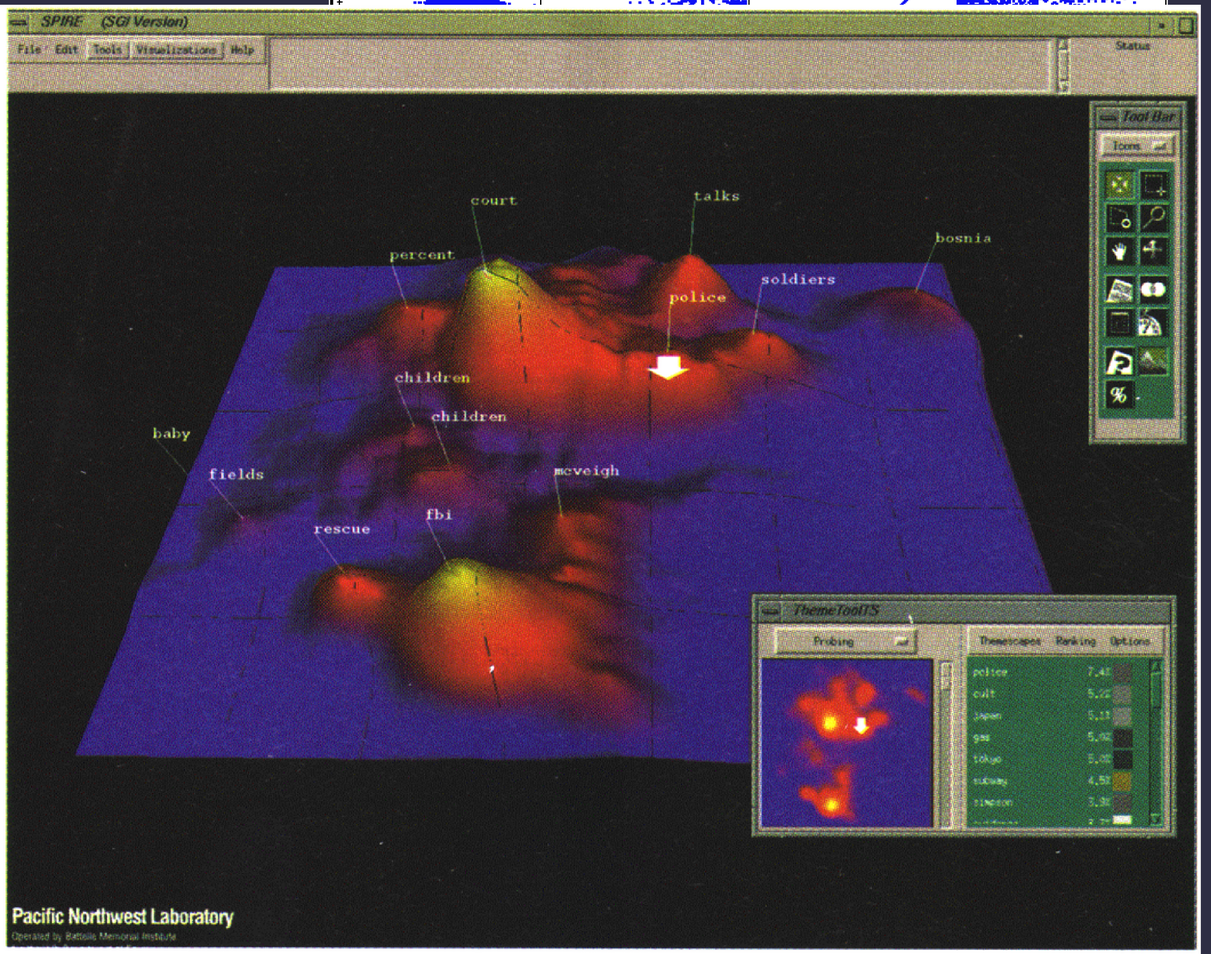


Graphic Displays

- Scatter Plot







Data Visualization

- Why data visualization?
  - gain insights, qualitative overview, explore
- Visualization methods
  - pixel-oriented, icon-based, hierarchical
  - geometric projection
  - visualizing complex data and relations

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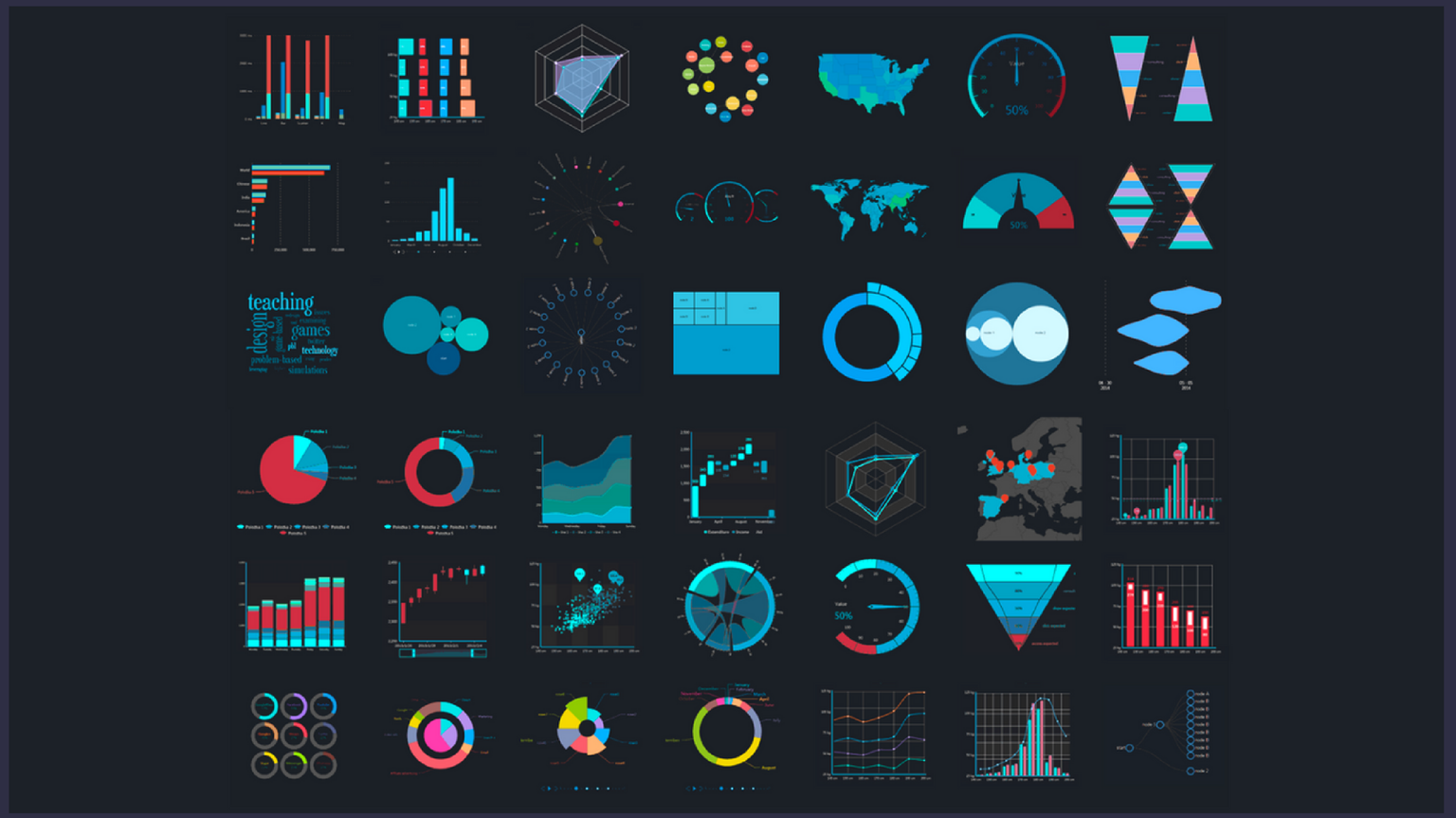
Data Visualization

- Examples of types of data visualization



Measuring Data Similarity

- Data matrix
  - object-by-attribute
  - two modes

$$\begin{bmatrix} x_{11} & \cdots & x_{1f} & \cdots & x_{1p} \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ x_{i1} & \cdots & x_{if} & \cdots & x_{ip} \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ x_{n1} & \cdots & x_{nf} & \cdots & x_{np} \end{bmatrix}$$

- Dissimilarity matrix
  - object-by-object
  - one mode

$$\begin{bmatrix} 0 & & & & \\ d(2,1) & 0 & & & \\ d(3,1) & d(3,2) & 0 & & \\ \vdots & \vdots & \vdots & & \\ d(n,1) & d(n,2) & \cdots & \cdots & 0 \end{bmatrix}$$

Object Similarity/Dissimilarity

- Usually measured by distance
  - Minkowski distance (Lp norm)

$$d(i,j) = (|x_{i1} - x_{j1}|^p + |x_{i2} - x_{j2}|^p + \cdots + |x_{in} - x_{jn}|^p)^{1/p}$$

  - Euclidean distance (L2 norm)

$$d(i,j) = \sqrt{(x_{i1} - x_{j1})^2 + (x_{i2} - x_{j2})^2 + \cdots + (x_{in} - x_{jn})^2}$$

  - Manhattan distance (L1 norm)

$$d(i,j) = |x_{i1} - x_{j1}| + |x_{i2} - x_{j2}| + \cdots + |x_{in} - x_{jn}|$$

  - Weighted distance

Nominal Attributes

- E.g., courses taken by different students
- Method 1: simple matching
  - d(i, j) = (p - m) / p
  - m: # of matches, p: total # of variables
- Method 2: view each state as a binary variable
  - e.g., degree (BS, BA, MS, PhD); then (0, 1, 0, 0) means BA

Summary

- Chapter 2: Getting to Know Your Data
  - Data objects and attribute types
  - Basic statistical description of data
  - Data visualization
  - Measuring data similarity and dissimilarity

Thank you

A special thank you to Qin Lv for her slides,
on which this lecture is based