Recap

- (Ch 1) Visualizing and summarizing data
  - Tables, bar charts, histograms , conditional histograms
  - Mean, standard deviation and variance

Today

- (Ch 1) Visualizing and summarizing data
  - Standardizing data to look at its shape
  - Median, interquartile range, box plots and outliers
- (Ch 2) Visualizing and summarizing relationships in data
  - Scatter plots
  - Correlation coefficient

Standard coordinates

- The mean tells where the data set is, and the standard deviation tells us how spread out it is, but what about its shape?
- Standardizing the data set shifts its mean to 0 and scales its standard deviation to 1.
- Given a data set $\{x\}$, we standardize it to the data set $\{\hat{x}\}$ as follows:

$$\hat{x}_i = \frac{x_i - \text{mean}(\{x\})}{\text{std}(\{x\})}$$

- We say $\{\hat{x}\}$ is in standard coordinates

Median → location parameter

- If there are an odd number of items,

$$\text{median} = \text{middle item when sorted}$$

- If there are an even number of items,

$$\text{median} = \text{mean of middle 2 items when sorted}$$

- The median is also known as the 50^{th} percentile

Properties of the median

- Scaling data scales the median

$$\text{median}(\{kx_i\}) = k\text{median}(\{x_i\})$$

- Translating data translates the median

$$\text{median}(\{x_i + c\}) = \text{median}(\{x_i\}) + c$$

Interquartile range

$$\text{iqr} = (75\text{th percentile}) - (25\text{th percentile})$$

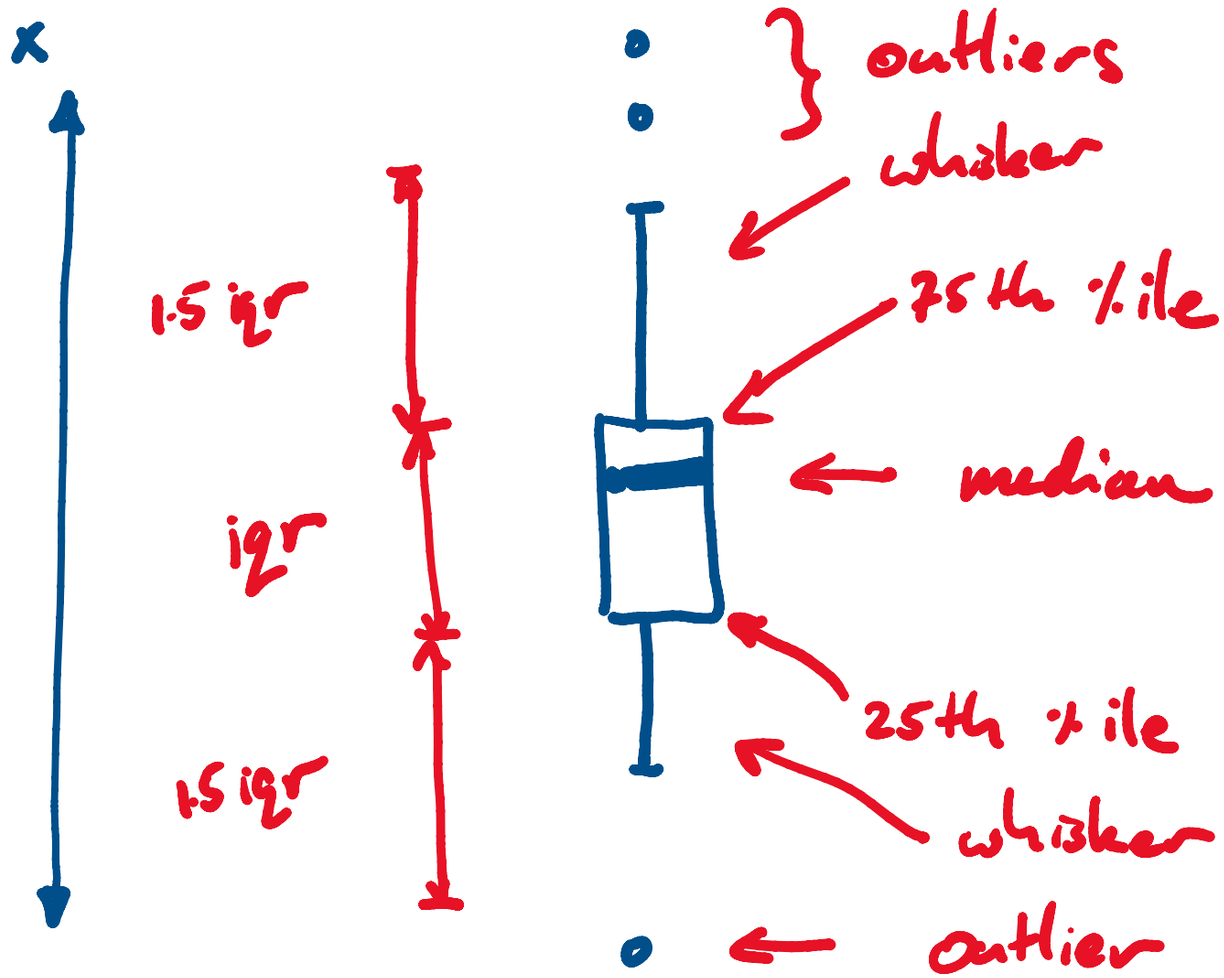
- Scaling data scales the interquartile range

$$\text{iqr}(\{kx_i\}) = |k|\text{iqr}(\{x_i\})$$

- Translating the data does **not** change the interquartile range

$$\text{iqr}(\{x_i + c\}) = \text{iqr}(\{x_i\})$$

Box plots



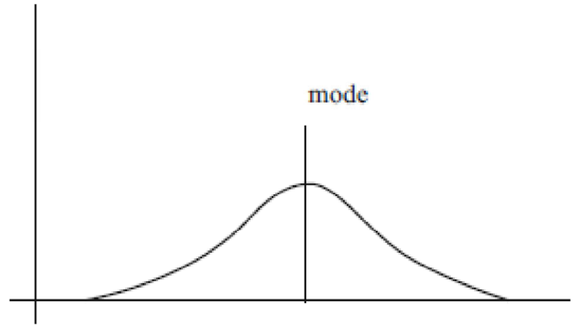
Boxplots are useful in identifying outliers, but you should think about how to justify discarding those outliers from your data set

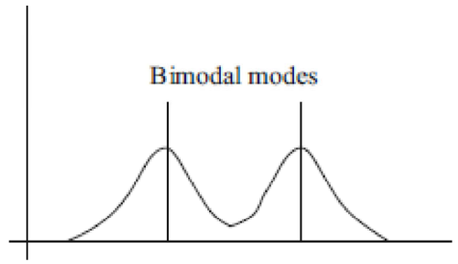
Sensitivity of summary statistics to outliers

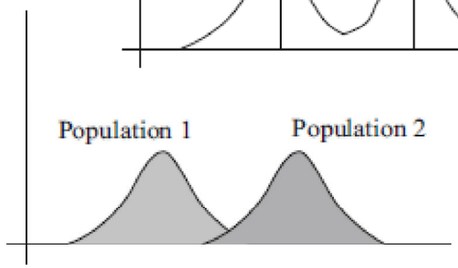
- Mean and standard deviation are very sensitive outliers
- Median and interquartile range are not sensitive to outliers

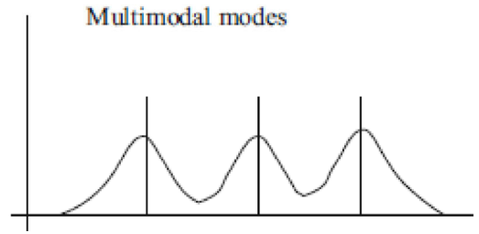
Modes

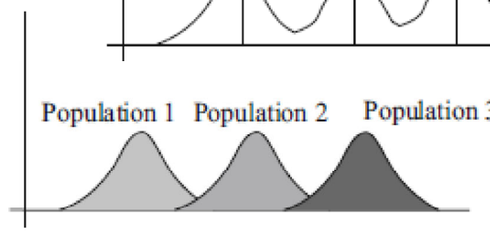
- Modes are peaks in a histogram
- If there is more than 1 mode, we should be curious as to why



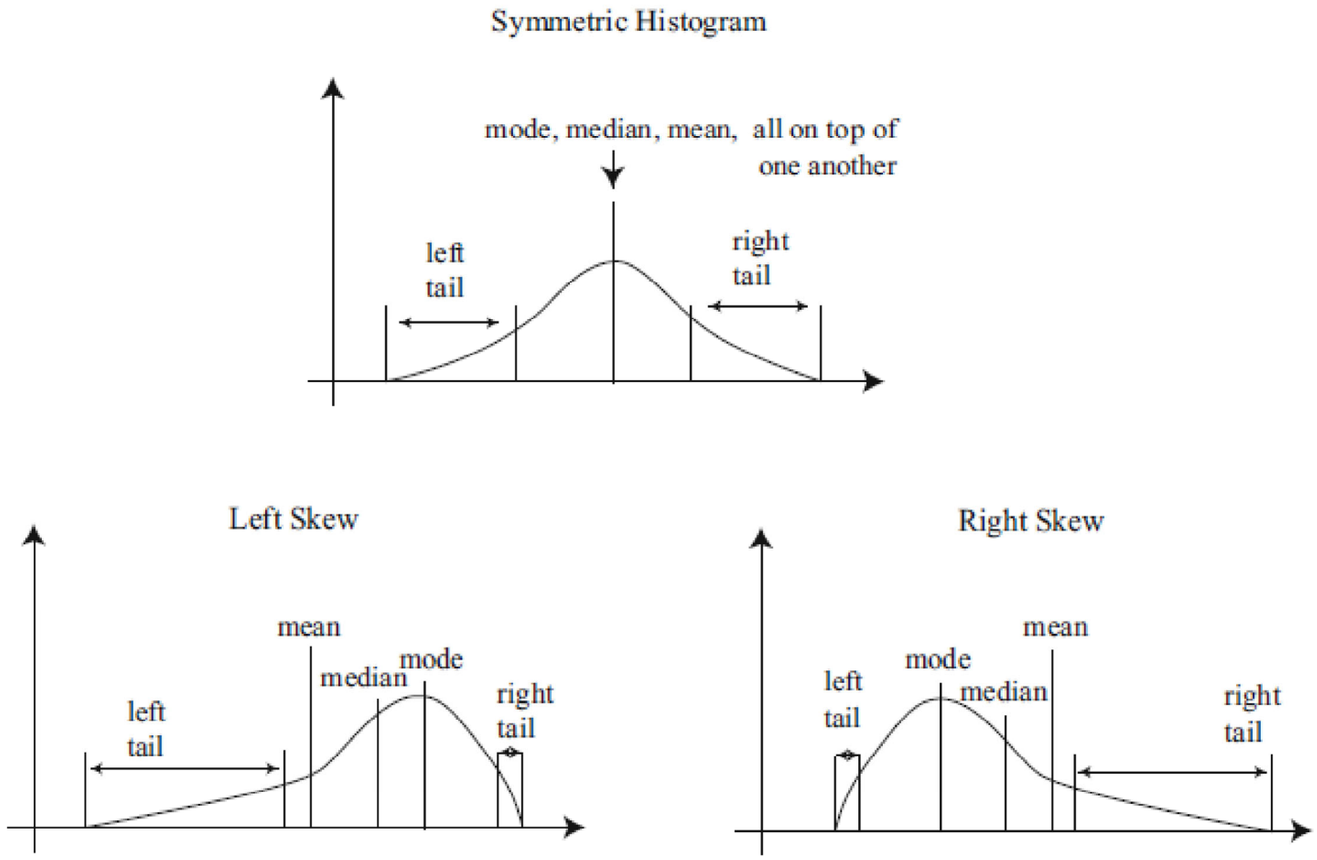








Tails and skew



Looking at relationships in data

Jupyter notebook example: Stock prices of Fedex and UPS

- Time series data
- Standardization
- Scatter plots
- The correlation coefficient

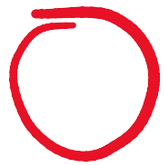
Correlation, a rough idea

In a data set $\{(x, y)\}$ consisting of items $(x_1, y_1), \ldots, (x_N, y_N)$

- we say x and y have **positive correlation** if
  - small x and small y tend to occur together
  - large x and large y tend to occur together

- we say x and y have **negative correlation** if
  - small x and large y tend to occur together
  - large x and small y tend to occur together

- we say x and y have **zero correlation** if
  - there is no tendency for x and y to be small together or large together



Correlation examples

- Lines of code in a codebase and number of bugs?

  positive

- Body temperature and height?

  zero

- GPA and hours spent playing video games?

  negative

- Earnings and happiness?

  who knows

Correlation does not imply causation!

Sleeping with your shoes on is positively correlated with waking up with a headache

Does sleeping with your shoes on cause headaches?