Descriptive statistics

Measures of central tendency

Measure	Formula	When to use
Mean ($\bar{x}$)	$\bar{x} = \frac{\sum x_i}{n} = \frac{x_1 + x_2 + \cdots + x_n}{n}$	No outliers; symmetric data
Median	Middle value when data is ordered	Outliers present; skewed data
Mode	Most frequent value	Categorical data; finding peaks

Example: Data: $3, 5, 7, 7, 9, 12, 28$

Mean $= \frac{3+5+7+7+9+12+28}{7} = \frac{71}{7} \approx 10.1$ Median $= 7$ (middle value) Mode $= 7$ (appears twice)

The outlier (28) pulls the mean up, but the median is resistant.

Measures of spread

Measure	Formula
Range	Range $=$ Max $-$ Min
Variance (sample)	$s^2 = \frac{\sum(x_i - \bar{x})^2}{n-1}$
Standard Deviation (sample)	$s = \sqrt{s^2} = \sqrt{\frac{\sum(x_i - \bar{x})^2}{n-1}}$
Interquartile Range (IQR)	IQR $= Q_3 - Q_1$

Note: For a **population**, use N instead of $n-1$ in the variance formula: $\sigma^2 = \frac{\sum(x_i - \mu)^2}{N}$

Example: Data: $2, 4, 6, 8, 10$ Mean: $\bar{x} = 6$

x_i	$x_i - \bar{x}$	$(x_i - \bar{x})^2$
2	-4	16
4	-2	4
6	0	0
8	2	4
10	4	16
		$\sum = 40$

$s^2 = \frac{40}{5-1} = 10$ $s = \sqrt{10} \approx 3.16$

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Quartiles and the five-number summary

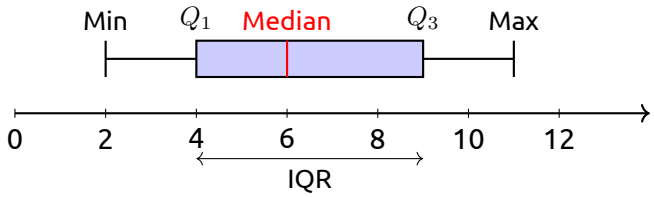
Order the data, then find:

- Q_1 (25th percentile): median of the lower half
- Q_2 (50th percentile): the median
- Q_3 (75th percentile): median of the upper half

Five-number summary: Min, Q_1, Median, Q_3, Max
Example: Data: $1, 3, 5, 7, 9, 11, 13, 15, 17$
Min $= 1$, $Q_1 = 4$, Median $= 9$, $Q_3 = 14$, Max $= 17$
IQR $= Q_3 - Q_1 = 14 - 4 = 10$

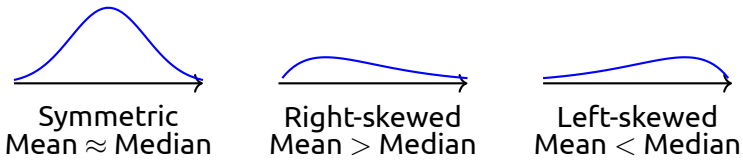
Boxplots

A boxplot displays the five-number summary graphically.



Outliers: Values below $Q_1 - 1.5 \cdot$ IQR or above $Q_3 + 1.5 \cdot$ IQR are outliers (plotted as individual points).

Shape of distributions



Tip: The mean is pulled toward the tail (toward the outliers/skew).

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