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Lecture title: **Statistiscs: Measures of Variation**

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Summary:

- **Measures of Variation (Dispersion)**

  It means how far or close the values of data are. It is the measurements of amount of variation between the values and its mean.

  - **Range (R)** $R = X_{max} - X_{min}$

    - it gives inappropriate weight to extreme values (overestimate the dispersion if the outliers present)

    Example: Xi = 12,6,7,3,15,10,18,5

    R = 18-3=15

    Xi= 9,8,9,7,3,8,9,9,8,18

    R = 18-3=15

  - **Mean Absolute Deviation (MAD):** The mean absolute deviation of a dataset is the average distance between each data point and the mean. It gives us an idea about the variability in a dataset.

    $$\text{MAD} = \frac{|\sum(xi - \bar{X})|}{n}$$

    How to calculate MAD?

Step 1: Calculate the mean.

Step 2: Calculate how far away each data point is from the mean using

positive distances. These are called absolute deviations.

Step 3: Add those deviations together.

Step 4: Divide the sum by the number of data points.

Example: Find the mean absolute deviation for the following data

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set:

10, 15, 15, 17, 18, 21

1. Calculate the mean=(10+15+15+17+17+18+21)/6 = 16
2. Calculate the absolute distance of each value from the mean

10	10-16	6
15	15-16	1
15	15-16	1
17	17-16	1
18	18-16	2
21	21-16	5

3. Add the distances together 6+1+1+1+2+5= 16
4. Divide the sum by the number of data points.
   MAD= 16/6≈3

- **Variance and Standard Deviation:** The variance is mathematically defined as **the average of the squared differences from the mean**. The sample variance, s^2, is used to calculate how varied a sample is. A sample is a select number of items taken from a population. Standard deviation is equal to the square root of the variance.

For samples:

$$\text{variance} = s^2 = \frac{\Sigma (x-\bar{x})^2}{n-1}$$

$$\text{standard deviation} = s = \sqrt{s^2}$$

For populations:

$$\text{variance} = \sigma^2 = \frac{\Sigma (x-\bar{x})^2}{n}$$

$$\text{standard deviation} = \sigma = \sqrt{\sigma^2}$$

<u>Note:</u>

1) Always consider observations as a sample except if mentioned it is a population.
2) The unit for variance is square cm^2, kg^2,……etc.
3) If variance is high, that means you have larger variability in your dataset. In the other way, we can say more values are spread out around your mean value.
4) When adding or subtracting any constant (k) form each value of a data set, the variance and standard deviation remain unchanged.
5) When multiplying each value of a data set with a constant (k), the new variance and new standard deviation will be:

New s^2 =old s^2 * k^2

New s =old s * k

Example: find the variance and the standard deviation for the values of X in the following table:

X	X - $\bar{X}$	(X - $\bar{X}$)^2
0	-15	225
24.1	9.1	82.81
5.6	-9.4	88.36
14.1	-0.9	0.81
17.2	2.2	4.84
8.7	-6.3	39.69
19.2	4.2	17.64
14.1	-0.9	0.81
27.7	12.7	161.29
15	0	0
19.3	4.3	18.49
		639.74

n =11

n-1=10

Mean ($\bar{x}$) =15

Sample variance (s^2) = 639.74/10 = 63.97

Sample standard deviation (S) = 8.00

- **Coefficient of variation (C.V %):** It is the ratio of the standard deviation to the mean (average). It is used to compare between two different samples for different populations.

Coefficient of Variation C.V = (Standard Deviation / Mean) * 100

$$C.V = \frac{S}{\bar{X}} * 100$$

<u>Example:</u>

Calculate the coefficient of standard deviation and coefficient of variation for the following sample data: 2, 4, 8, 6, 10, and 12.

X	$\left(X-\overline{X}\right)^2$
2	$(2-7)^2 = 25$
4	$(4-7)^2 = 9$
8	$(8-7)^2 = 1$
6	$(6-7)^2 = 1$
10	$(10-7)^2 = 9$
12	$(12-7)^2 = 25$
$\sum X = 42$	$\sum\left(X-\overline{X}\right)^2 = 70$

$$\overline{X} = \frac{\sum X}{n} = \frac{42}{6} = 7$$

$$S = \sqrt{\frac{\sum\left(X-\overline{X}\right)^2}{n}}$$

$$S = \sqrt{\frac{70}{6}} = \sqrt{\frac{35}{3}} = 3.42$$

$$\text{Coefficient of Standard Deviation} = \frac{S}{\overline{X}} = \frac{3.42}{7} = 0.49$$

Coefficient of Variation

$$(C.V) = \frac{S}{\overline{X}} \times 100 = \frac{3.42}{7} \times 100 = 48.86\%$$

Example: A group of 80 candidates have their average height is 145.8 cm with coefficient of variance 2.5%. What is the standard deviation of their height?

$$CV = \frac{S}{\bar{X}} *100$$

$$2.5 = S / 145.8$$