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DEPARTMENT OF BIOMEDICAL ENGINEERING

III Semester- BM3301 SENSORS AND MEASUREMENTS

UNIT -1

1.6 Errors & Statistical Analysis

1.6.1 STATISTICAL TREATMENT OF DATA:

The experimental data is obtained in two forms of tests :

(i) Multisample test and (ii) Single-sample test.

Multisample test: In this test, repeated measurement of a given quantity are done using different test conditions such as employing different instruments, different ways of measurement and by employing different observers. Simply making measurements with the same equipment, procedure, technique and same observer do not provide multisample results.

Single-sample test: A single measurement (or succession of measurements) done under identical conditions excepting for time is known as single-sample test. In order to get the exact value of the quantity under measurement, tests should be done using as many different procedures, techniques and experimenters as practicable.

1.6.2 Histogram

When a number of multisample observations are taken experimentally there is a scatter of the data about some central value. One method presenting test results in the form of a Histogram. The technique is illustrated in Figure representing the data given in Table.

This table shows a set of fifty readings of a length measurement.

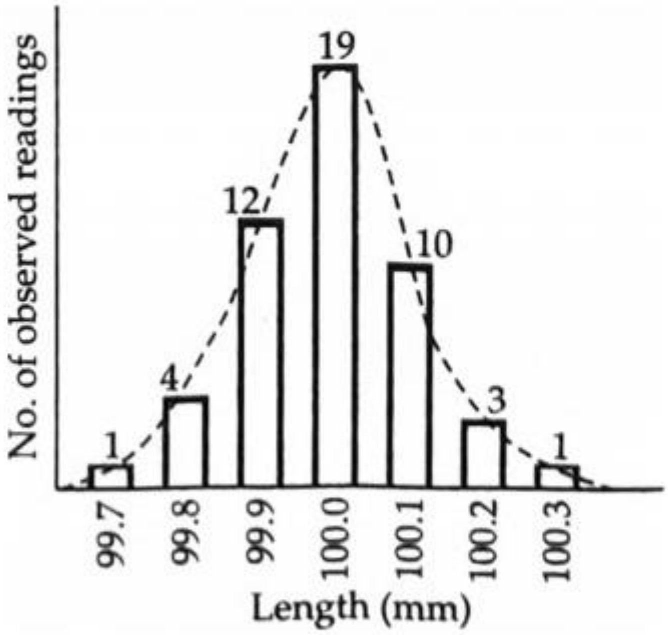
Length(mm)	No.of Readings
99.7	1

99.8	4
99.9	12
100.0	19
100.1	10
100.2	3
100.3	1

Total No. of Readings = 50

The most probable or central value of length is 100

his histogram of Figure represents these data where the ordinate indicates the number of observed readings (frequency or occurrence) of a particular value. A histogram is also called a frequency distribution curve.



Histogram

1.6.3 Arithmetic Mean:

$$\overline{X} = \frac{x_1 + x_2 + x_3 + x_4 + \ldots + x_n}{n} = \frac{\sum x}{n} \qquad \ldots(3.16)$$

where, $\overline{X}$ = arithmetic mean.

$x_1, x_2, \ldots, x_n$ = readings or variates or samples.

and n = number of readings.

1.6.4 Deviation:

Deviation is departure of the observed reading from the arithmetic mean of the group of readings. Let the deviation of reading x_1 be d_1 and that of reading x_2 be d_2, etc.

Then,

$$d_1 = x_1 - \overline{X}$$
$$d_2 = x_2 - \overline{X}$$
$$\cdots\cdots\cdots\cdots\cdots\cdots$$
$$d_n = x_n - \overline{X}$$
$$\overline{X} = \frac{\Sigma(x_n - d_n)}{n}$$

Algebraic sum of deviations

$$= d_1 + d_2 + d_3 + \ldots + d_n$$
$$= (x_1 - \overline{X}) + (x_2 - \overline{X}) + (x_3 - \overline{X}) + \ldots + (x_n - \overline{X})$$
$$= (x_1 + x_2 + x_3 + \ldots + x_n) - n\overline{X} = 0$$

as $x_1 + x_2 + x_3 + \ldots + x_n = n\overline{X}$

Therefore the algebraic sum of deviations is zero.

1.6.5 Average Deviation:

Average deviation is defined as the sum of the absolute values of deviations divided by the number of readings.

Average deviation may be expressed as,

$$\overline{D} = \frac{|-d_1| + |-d_2| + |-d_3| + \ldots + |-d_n|}{n} = \frac{\Sigma|d|}{n}$$

1.6.6 Standard Deviation (S.D.):

The Standard Deviation of an infinite number of data is defined as the square root of the sum of the individual deviations squared, divided by the number of readings.

Thus standard deviation is :

$$\text{S.D.} = \sigma = \sqrt{\frac{d_1^2 + d_2^2 + \ldots + d_n^2}{n}} = \sqrt{\frac{\Sigma d^2}{n}}$$

In practice, however, the number of observations is finite. When the number of observations is greater than 20, S.D. is denoted by symbol o while if the number of observations is less than 20, the symbol used is s. The Standard Deviation of a finite number of data is given by,

$$s = \sqrt{\frac{d_1^2 + d_2^2 + d_3^2 + \ldots + d_n^2}{n-1}} = \sqrt{\frac{\Sigma d^2}{n-1}}$$

1.6.7 Variance:

The variance is the mean square deviation, which is the same as S.D., except that square root is not extracted.

$$\text{Variance } V = (\text{Standard Deviation})^2$$
$$= (\text{S.D.})^2 = \sigma^2 = \frac{d_1^2 + d_2^2 + d_3^2 + \ldots + d_n^2}{n}$$
$$= \frac{\Sigma d^2}{n}$$

But when the number of observations is less than 20

$$\text{Variance } \; V = s^2 = \frac{\Sigma d^2}{n-1}$$