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The weighted mean and its improved dispersion

L E Grigorescu
Horia Hulubei National Institute of Physics and Nuclear Engineering, Romania

Statistics is involved in every physical measurement.The weighted mean appears when a physical quantity is measured by different methods in different laboratories, producing different results. The formula is: The formula is:

$$\bar{x}_w = \frac{\sum w_i x_i}{\sum w_i} = \sum p_i x_i \quad (1)$$

with w_i -absolute weights and p_i - relative weights.

A relation exists:

$$w_i = \frac{1}{\sigma_i^2} \quad (2)$$

with - the individual standard deviations.

To $\bar{x}_w$, two different dispersions are associated, D_1 (internal) and D_2 (external).

The ratio D2/D1 is:

$$\frac{D_2}{D_1} = \sum w_i (x_i - \bar{x}_w)^2 = \sum \frac{(x_i - \bar{x}_w)^2}{\sigma_i^2} = \sum r_i^2 \quad (3)$$

In practice (D2/D1)>1. So D_2 is the confident one.

In principle $\bar{x}_w$ should produce as great deviations $(x_i - \bar{x}_w)$ as the associated are great.

For equal treatment of these deviations, relative deviations may be considered:

$$d_i = \frac{x_i - \bar{x}_w}{\sigma_i} \quad (4)$$

which express the deviations in units .

The n values from (4) must have same near (equivalent) values.Their arithmetical mean tends to zero.Thus, as in the case of a unique , we may reach the minimum of the expression:

$$\sum_1^n \frac{(x_i - \bar{x}_w)^2}{\sigma_i^2} \quad (5)$$

The annulation of the derivative for , gives:

$$\sum_1^n \frac{(x_i - \bar{x}_w)}{\sigma_i^2} = \sum_1^n \frac{x_i}{\sigma_i^2} - \bar{x}_w \sum_1^n \frac{1}{\sigma_i^2} = 0 \quad (6)$$

and finally formulas (1) and (2) are obtained.

This calculus accepts great even with systematic uncertainties.In practice the theoretical unknown values , are replaced in formulae (1), (2) by the experimental value , which fluctuate.

A dispersion D3 is obtained, by error propagation, and added to D1, D2.

First are calculates:

$$\frac{\partial \bar{x}_w}{\partial w_i} = \frac{x_i \sum w_i - \sum w_i x_i}{(\sum w_i)^2} = \frac{x_i - \bar{x}_w}{\sum w_i} \quad (7)$$