‘Adjustment Theory’

Lecture-1

Introduction to Adjustment Theory

By
Bakhtyar Ahmed Mala

Outline

- Definition of Adjustment theory
- Facts about the measurement
- Errors and Residuals
- Types of errors
- Sources of errors
- Some definitions
- Weight

➢ Adjustment Theory

Adjustment: It is the process of finding the nearest value to the true value for the measured observations.

All measurements must be processed before using them for special purpose because all measurements contain error.

Methods of Processing

- ➢ Measurements must be processed statistically to assess their values whether they are acceptable or not.

If yes ---- ok
If not ---- rejected and to be repeated

- ➢ Adjust the measurements to conform with geometric condition.

- The subject of the adjustment is random errors. Adjustment does not eliminate the errors, but distributes errors according to a certain rule.
- The modern measurement techniques produce redundant measurements, which are better evaluated using the method generally referred to as least squares estimation or least squares adjustment.
- Today, the traditional methods of adjusting measurements are inadequate for precision surveys.

➢ Facts about the measurement

Types of measurements:

1. **Direct measurement:** applying an instrument and taking the readings on it's scale (when measurements are measured directly)
2. **Indirect measurement:** it is required coordinate to derive their measurements (angle, distance). (when measurements deduced from other quantities)

Facts about measurements:

1. No measurement is exact
2. Every measurement contains error.
3. The true value of a measurement is **never** known
4. The true error is never known too

➢ Errors and Residuals

Error: is the difference between measured value and the true value of the quantity.

Error (ei) = measured value (xi) –true value(x)

e = x – x'

e: error

x: measured value of the quantity

x': is the true value of the quantity

residual: is the different between measured value and most probable value (MPV), (mean value) of the quantity.

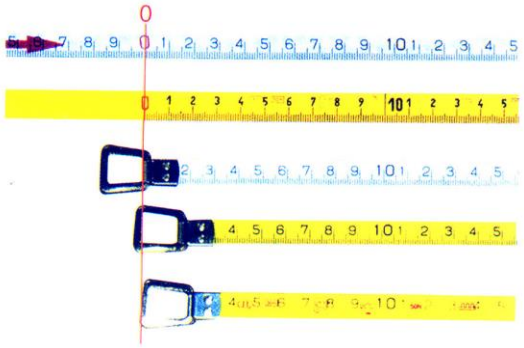
vi (r) = xi- x' (mean)

Residuals are similar to errors but can be calculated. Errors cannot be calculated

➢ Types of errors

1- Systematic errors: they are happening according to physical law. They are constant magnitude in each measurement step condition. Also called cumulative errors or biases.

They may be corrected mathematically or by changing the procedure of the measurement.



2- Random error (accidental error): are errors remaining in the measurements after the corrections of systematic errors and mistakes (gross-errors). Usually they are of small magnitude and its (negative and positive) signs.

Random errors are also called compensating errors. Since they tend to partially cancel themselves in a series of observations. Their effect is minimized by adjustment methods.

3- Mistake (blunders/gross errors): they happen in measurements due to confusion and carelessness of the observer.

They are corrected by repeating the measurement.

Ex. 169.78 196.78

Measured writing

➢ Sources of errors

1. **Instrumental error:** due to imperfection of manufacturing the instrument.
2. **Natural errors:** it's due to variation in the condition of the environment surrounding the instrument (ex. Temperature, pressure gravity,…..).
3. **Personal errors:** it is from the person who makes the measurement.

➢ Some definitions

True Value: it is a value of a quantity which is free from all errors. Because it is not possible to eliminate all the errors completely from a measurements. The true value can not be determined.

Observations: The measured numerical value of a quantity is known as observation. It may be classified as direct and indirect observations.

Observed value of a quantity: is the value obtained from the observation after eliminating the mistakes and systematic error. It is classified as dependent and independent quantities.

Dependent quantities (conditioned quantities): if the value of an observed quantity is dependent up on the value of other quantities it is called conditioned quantity.

Independent quantity: if the value of an observed quantity is independent of the value of other quantities it is said to be an independent quantity.

Most Probable Error: it may be defined as the quantity which is subtracted from or added to the most probable value of quantity.

$S > \mu \pm$ M.P.E

Weight of Observations: a measurements of high precision has a small variance and conversely. A measurements of low precision has a large variance.

The value of variance goes in opposite direction to that of the precision.

There are another measure of precision that is directly related to the precision of the measurement, and does not be have in opposite manner as variance, this measure is called "**weight**" of the observation. And is always expressed in a positive number for any given observation.

The higher the weight the higher the precision and vice versa.

Accordingly, the weight 'W' of a single observation is defined as a quantity that is inversely proportional to the variance (σ^2) of the observation.

$$w = \frac{k}{\sigma^2}$$

Where k: is the constant

Assume that there is an observation with standard error σ_0 and weight $w_0 = 1$ the equation of weight gives.

$$1 = \frac{k}{\sigma_0^2}\ then\ k = \sigma_0^2$$

The arbitrary constant (k) is equal to the variance of observation with unit weight = 1, therefore σ_0 is called the standard error of unit weight, and $k = \sigma_0^2$ is called "variance factor" or 'unit weight variance' or reference variance.

So the equation can be written as

$$w_i = \frac{\sigma_0^2}{\sigma_i^2}$$

Laws of weight

The method of least squares for errors adapts the following laws of weights.

1. The weight of the arithmetic mean of a number of observations of unit weight is equal to the number of the observations.
2. The weight of the weighted arithmetic mean of a number of observations is equal to the sum of individual weights of observations.
3. The weight of the sum of the quantities added algebraically, is equal to the reciprocal of the sum of the reciprocals of the individual weights.

4. The weight of the product of any quantity multiplied by a constant, is equal to the weight of that quantity divided by the square of that constant.
5. The weight of the quotient (amount of something) of any quantity divided by a constant, is equal to the weight of that quantity multiplied by the square of that constant.
6. The weight of an equation remains unchanged if all the signs of the equation are changed.
7. The weight of an equation remains unchanged if the equation is added to, or subtracted from a constant.

8. If an equation is multiplied by its own weight, the weight of the resulting equation is equal to the reciprocal of the weight of that equation.