Yildiz Technical University
Faculty of Civil Engineering
Department of Geomatic Engineering

TOPOGRAPHY (HRT3351)

Lecture Notes

Prof. Dr. Burak AKPINAR

Title	Code	Local Credit	ECTS	Lecture (hour/week)	Practical (hour/week)	Laboratory (hour/week)
Topography	HRT3351	3	4	3	0	0

Course Objectives	The aim of this course, gains required skills of basic of surveying techniques, mathematical definitions using for large scale map production.

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WEEKLY SUBJECTS

Week	Subject
1	Introduction to Topography
2	Measurement Units and Sources of Measurement Errors
3	Types of Errors
4	Coordinate Systems and Map Projections
5	Geodetic Network Points and Distance Measurements
6	Direction Measurements
7	Traverse Computations
8	Height Measurements
9	Midterm exam 1
10	Area and Volume Computations
11	Field work
12	Field work
13	Geographic Information System, GIS
14	Midterm exam 2
15	GNSS Global Positioning Systems
16	Final exam

Week-3
Types of Errors

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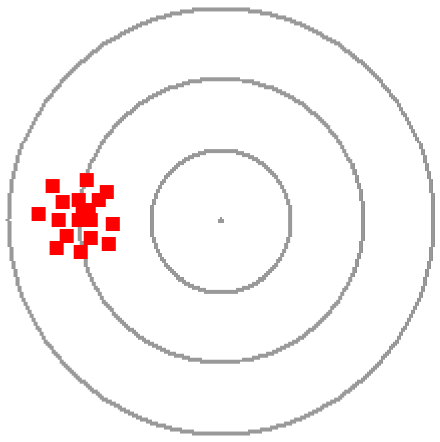
Types of Error

- Types of Error
  - Systematic Error
  - Random Error
  - Mistake (Blunder)

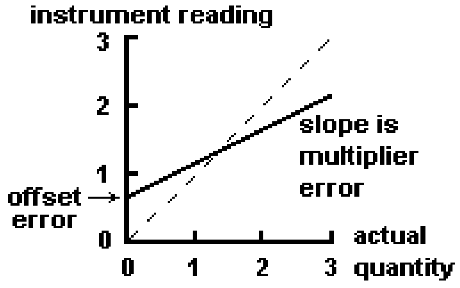
Systematic Error

Systematic error is a type of error that deviates by a fixed amount from the true value of measurement.


Systematic Error

Systematic errors in experimental observations usually come from the measuring instruments. They may occur because:
- there is something wrong with the instrument or its data handling system, or
- because the instrument is wrongly used by the experimenter.

Two types of systematic error can occur with instruments having a linear response:
1. Offset or zero setting error.
2. Multiplier or scale factor error



Correcting Systematic Errors

Because systematic errors are caused by the physics of the measurement system, they can be mathematically modeled and corrections computed to offset these errors.

For example temperature correction for a steel tape:

$$C = k\,(T_m - T_s)L$$

Where k is a constant:, (6.45×10^{-6} for degrees Fahrenheit) ; T_m is the temperature of the tape; T_s is the standard temperature; and L is the uncorrected length measured. If the temperature is above standard, then the tape is too long, and a measured distance will be too short.

Correcting Systematic Errors

Total Station EDM Corrections for Systematic Errors

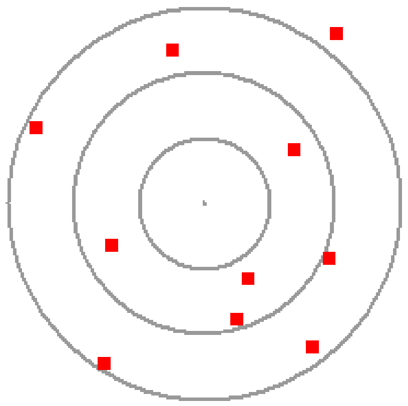
- The EDM (Electronic Distance Measurement) part of a total station measures distances using light waves. The velocity of light in air varies according to the air density. If the operator enters air temperature and pressure, the systematic error caused by this variation is corrected by most total stations.

- If the survey not at sea level, using sea level pressure introduces a systematic error. This error, of course, increases with elevation. Ignoring the correction at an elevation of 900 feet causes a distance error of about 10 ppm (parts per million).

Random Error

Random errors in experimental measurements are caused by unknown and unpredictable changes in the experiment. These changes may occur in the measuring instruments or in the environmental conditions.

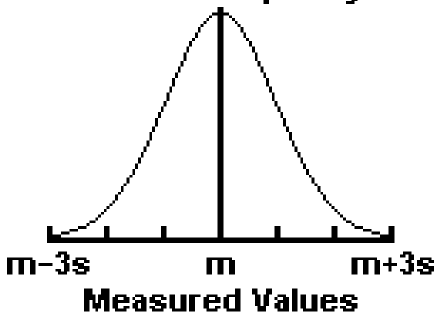
Examples of causes of random errors are:
- electronic noise in the circuit of an electrical instrument,
- irregular changes in the heat loss rate from a solar collector due to changes in the wind.



Random Error

Random errors often have a Gaussian normal distribution. In such cases statistical methods may be used to analyze the data.

The mean m of a number of measurements of the same quantity is the best estimate of that quantity, and the standard deviation s of the measurements shows the accuracy of the estimate.



<u>There is no absolute way to compute or eliminate them, but they can be estimated using adjustment procedures.</u>

Mistake (Blunder)

A blunder is an observation that is in error by more than the typical systematic or random error normally encountered.

It's a BIG error that happened because two numbers were transposed or the wrong back sight point was sighted.

Blunders are generally 'one time' errors that don't appear elsewhere in the survey.

Comparing several observations of the same quantity is one of the best ways to identify mistakes.

Assume that five observations of a line are recorded as; 67.91, 76.95, 67.89, 67.90, 67.89. The second value disagrees with the others, apparently because of a transposition of figures in reading or recording.

Most Probable Value (Expected Value) (x)

The true of any quantity is never known. However, its most probable value can be calculated if redundant observations have been made. Redundant observations are measurements in excess of minimum required to determine a quantity.

Most probably value is derived from a sample set of data rather than the population, and simply the mean if the repeated measurements have the same precision.

For a single unknown such as a line length that has been directly and independently observed a number of times using the same equipments and procedures, the most probable value in this case simply the arithmetic mean;

$x = (\Sigma l / n)$

Σl = the sum of the individual measurements y,

n = the total number of observations

Residuals

It is the differences between any individual measured quantity and the most probable value for that quantity.
The mathematical expression for a residual is;
$V_i = x - l_i$
Where V_i is the residual in any observation l_i and x is the most probable value for the quantity.

$\Sigma V_i = 0 \qquad [V] = 0$;

Absolute error:

When the true value of a observation is known it is possible to calculate absolute error with following formula:

$$\varepsilon = x - l$$

Where x is the real value and l is the observation.

Example-1

Internal angels of a triangle were measured as following values:

α = $75^g.4525$

β = $67^g.2237$

γ = $57^g.3251$

Please determine the error.

Total value of internal angels of a triangle is 180^0 (200^g).

So that x = 200^g.

Absolute error: $\boldsymbol{\varepsilon = x - l}$

$\varepsilon = 200 - (\alpha + \beta + \gamma) = -0.0013^g = -13^{cc}$

Average Error

1. Average error (Average of absolute error)(t):

$$t = \pm \frac{|\varepsilon 1| + |\varepsilon 2| + |\varepsilon 3| + \ldots + |\varepsilon n|}{n} = \pm \frac{[|\varepsilon|]}{n}$$

ε = errors

n = number of observation

$$t = \pm \frac{|v1| + |v2| + |v3| + \ldots + |vn|}{n} = \pm \frac{[|v|]}{n}$$

V = residuals

Root Mean Square Error

2. Root Mean Square Error (m):

$$m = \pm\frac{\sqrt{|\varepsilon 1^2|+|\varepsilon 2^2|+|\varepsilon 3^2|+\ldots+|\varepsilon n^2|}}{n} = \pm\sqrt{\frac{[|\varepsilon\varepsilon|]}{n}}$$

ε = errors

n = number of observations

$$m = \pm\frac{\sqrt{|v1^2|+|v2^2|+|v3^2|+\ldots+|vn^2|}}{n-1} = \pm\sqrt{\frac{[|vv|]}{n-1}}$$

V = residuals

n-1 = redundant observations

$$m = \pm\sqrt{\frac{[|vv|]}{n-u}}$$

If two or more unknowns are exists,

u = number of unknowns n= number of observations

(n-u) = redundant observations

RMSE of most probable value
RMSE of the mean

$$M = \pm\frac{m}{\sqrt{n}}$$

Example - 2

The length of the one edge of a traverse is measured in both direction. As the measurements and the error tolerance is given, please determine if the measurements are tolerable.

Forward: 121.20 m.

Backward: 121.25 m

Error tolerance:

$$d = 0.005\sqrt{S} + 0.00015 * S + 0.0015\, m$$

Example - 2

$$S = \frac{Forward + Backward}{2} = 121.225m$$

Mean value

$$d = 0.075 = 0.08m = 8cm$$

Forward - Backward = 5 cm < d = 8 cm.

Measurements are tolerable and mean is considered as length.

Example - 3

A distance is measured 7 times and following measurements are obtained.

Observations (m):

$l_1 = 125.165$ $l_4 = 125.160$

$l_2 = 125.162$ $l_5 = 125.161$ $l_7 = 125.164$

$l_3 = 125.166$ $l_6 = 125.163$

Depending on above stated measurement values, please calculate:

a) Most probable value (x)
b) Average error (t)
b) Root Mean Square Error (m)
c) RMSE of most probable value (M)

Example - 3

Obs. Num	Measurements (l) m	Probable Val. (x). m	Residual (v) mm	v*v
1	125.165	125.163	-2	4
2	125.162		1	1
3	125.166		-3	9
4	125.160		3	9
5	125.161		2	4
6	125.163		0	0
7	125.164		-1	1
Total			0	28

a) Most probable value (x)

x= [l]/n =125.163

Example - 3

b) Average error (t)

$$t = \pm \frac{[|v|]}{n} \qquad [|v|] = 12mm$$

$$t = \pm \frac{[|v|]}{n} = \frac{12}{7} = \pm 1.7mm$$

Example - 3

c) Root Mean Square Error (m)

$$m = \pm\sqrt{\frac{[vv]}{n-1}}$$

$$m = \pm\sqrt{\frac{[vv]}{n-1}} = \pm\sqrt{\frac{28}{6}} = \pm 2.16mm$$

Example - 3

d) RMSE of most probable value (M)

$$M = \pm \frac{m}{\sqrt{n}} \qquad m = \pm\sqrt{\frac{[vv]}{n-1}}$$

$$M = \pm \frac{2.16}{\sqrt{7}} = \pm 0.82mm$$

Week-4
Coordinate Systems and Map Projections

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