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The Triangulation Reduction Analysis of Acute Triangle

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Abstract

Positioning on the surface of the earth using the triangulation method can be done in two ways, namely terrestrial method for example by measuring the angle and distance using the total station tool and extraterrestrial methods for example by using satellite-based positioning technology. Extraterrestrial positioning method using the global navigation satellite system combined with terrestrial methods by measuring angles and distances using the total station tool is one alternative to positioning well. In this study position determination will only be calculated using two intermediate calculation plane, on the ellipsoid projection and in the plane projection. Of course, in a process of measuring position for the same point but using different methods it will produce different levels of accuracy. From the results of the comparison in determining the definitive coordinate value generated by the count on the ellipsoid projection with the Gauss-Helmert method, the definitive value that is closer to the reference value measured by static measurements methods rather than definitive coordinates produced through calculations in the plane projection.

Keywords: extraterrestrial, positioning, terrestrial, triangulation.

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1. Preliminary

1.1. Background

Geodesy is the study of determining the shape and size of the earth in three-dimensional space that changes with time [1]. From these definitions, three main areas of study can be classified from geodetic positioning science, determining the earth's gravity field, and spatial and temporal variations of both. Determination of the position on the surface of the earth can be done in two ways, the terrestrial way for example by measuring angles and distances using a Total Station tool and the extraterrestrial way for example by using GPS technology. Positioning the extraterrestrial way using GPS combined with the terrestrial way by measuring angles and distances using a Total Station tool, is one alternative to positioning well. Positioning using the terrestrial method can be calculated using 3 count intermediate plane, namely on the surface of a two-dimensional ellipsoid (φ, λ), in a two-dimensional projection plane (x, y), and in a three-dimensional topocentric plane (n, e, u). In this research the determination of position only be calculated using two intermediate arithmetic plane, in the ellipsoid surface and in the projection plane. Of course, in a process of measuring position for the same point but using different methods, will produce a different level of accuracy. So the problem is measuring position with different methode will get different value of coordinate too. With this study it can be shown the difference accuracy coordinate in triangulation.

1.2. Formulation of the problem

How is the coordinates deviation of the triangulation of the acute triangulation with the base distance and the angle measured by the Total Station against the definitive coordinates of the results of the Static GPS measurement using Ellipsoid (Gauss-Helmert) method and Least Square Method.

1.3. Purpose and Objectives Research

The purpose of this research is:

1. Knowing the extent of differences in the position measurement results with the Total Station which is calculated by intermediate counts in the ellipsoid field and counts in the flat field against the position measurement data using GPS static methods.
2. Provides an understanding of alternative positioning using the Total Station tool.

The purpose of this study is to compare the level of accuracy of the coordinates of terrestrial survey measurement results using a total station tool that is calculated through the ellipsoid method with the flat plane method to the GPS survey measurement data using the static method.

1.4. The scope of research

This research has the following scope of research:

1. Comparative data were obtained from GPS survey data using the radial static method.

2. Position measurements through terrestrial measurements, carried out using the Total Station triangulation method.
3. The determination of coordinates is obtained from intermediate counts in the ellipsoid plane and in the flat plane.
4. Comparing the accuracy of the linear position calculated results through ellipsoid and flat field reduction with GPS Static survey measurement data.
5. The study area is located in the Diponegoro University campus area, the Semarang Army Military Training Field, the Central Java Grand Mosque area, and the campus area of the University of Muhammadiyah Semarang, Central Java.
6. Undulation and vertical deflection is 0.

2. Basic Theory

2.1. Map Projection

Map projection is a mathematical model to convert the three-dimensional position of a point on the surface of the earth to a two-dimensional representation of the position on the map (flat plane) [2].

Because the ellipsoid is in the projection plane, the distance in the ellipsoid (geodesic distance) also has a different length from the projection distance. When measuring horizontal angles, the vertical axis of the Total Station must coincide with the direction of the gravity vector. In order for the horizontal angle to refer to the reference ellipsoid, the horizontal angle must be corrected with a vertical deflection effect. The following is an equation to look for the effects of vertical deflection [3]

$$\delta\theta" = \ -(\xi_1 sin\alpha_{12} - \eta_1 cos\alpha_{12}) cot z \tag{1}$$

ξ_1, η_1 = vertical deflection component at P_1

z = zenith angle from the point P_1 ke P_2

2.2. UTM (Universal Transverse Mercator)

UTM is actually a TM projection field divided by each zone by 6 degrees, with universal provisions. This grid and projection system can be used both for topographic mapping work, references for satellite imagery and other applications that require precision for positioning [2]

The characteristics of the UTM grid system are:

1. It has a zone width of 6 degrees divided symmetrically in the east-west direction by the central meridian, and in the north-south direction by the equator.
2. The zero point (origin) of the coordinates for each zone is the intersection of the central meridian with the equator line.
3. Using a two-dimensional coordinate system (x, y) or expressed as (east, north), where the x-axis (east or easting) coincides with the equator and leads east to the map and the y-axis (north or northing) coincides with the central meridian and leads to the north of the map.
4. The scale factor on the central meridian is 0.9996.
5. For the southern hemisphere the false northing value of 10,000,000 meters can be used, and for the eastern hemisphere a false easting value of 500,000 meters is used.
6. The zone numbering rule starts from zone 1, which is at 180 degrees BB and 174 degrees BB meridian, then rises to zone 60, which is at 174 degrees BB and 180 degrees BB meridians.
7. Latitude coverage for each zone is 80 degrees north and 180 degrees south.

3. Research Implementation

3.1. Research Stages

The stages in carrying out this research outline consist of preparation, data collection, calculation, analysis of calculation results. The Figure 1 is flowchart of this research methods:

3.2. Preparation

This stage includes the study of literature and the determination of research locations. Literature studies are carried out on reference books relating to research topics. This is to deepen and broaden horizons and add information related to the scope of the research topic.

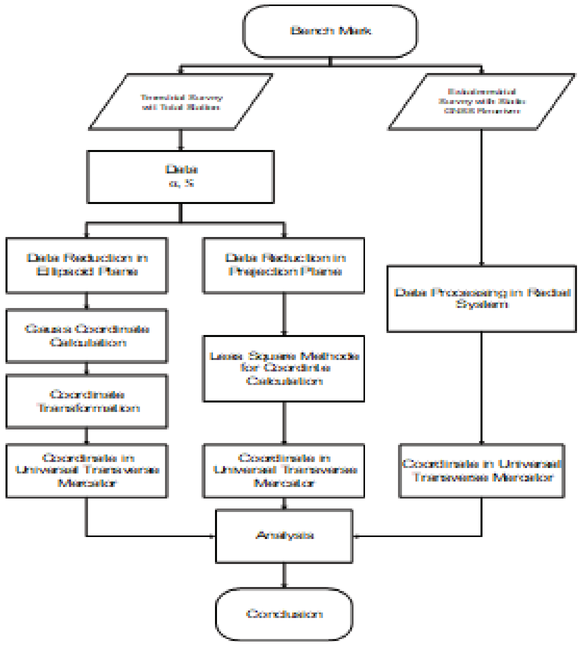

Figure 1: Flowchart of Research Method.

The next stage in the preparation stage is the site survey that will be used as a research site. In here do plan placement of points to represent the research location positioning, then in doing the marking to be easily identifiable point.

4. Results and Discussion

4.1. Measurement Implementation

The measurement is carried out to get the data that will be calculated in this research. GPS measurements produce coordinate data that will serve as a reference point for the calculated data from terrestrial measurements with the Total Station. In order to elaborate the analysis, in this study two measurements were made with different observation points. Each measurement consists of 3 observation points.

4.2. Research 1

The first study, observation points placed in the campus area of Diponegoro University, Tembalang, Military Army Training Field, Semarang, and in the rice fields of the Great Mosque of Central Java, Semarang, Central Java.

1. GPS measurement

GPS measurement is carried out to obtain position data for observation points for reference or as a reference data to be compared with the calculated data obtained from the calculation process of measurement data with Total Station. GPS measurements in this study use static methods.

2. GPS Data Processing

After GPS measurements are done, the data is processed in order to obtain the coordinates of the observation points. GPS data processing is done using TOPCON tools software.

The results of the coordinates obtained from processing GPS data with this software show in Table 1:

Table 1: Results of UTM Coordinates in Research 1.

Control Points			
Name	**Grid Northing (m)**	**Easting Grid (m)**	**Elevation (m)**
base0730a_T81S	9219941,183	435045,625	253,949
Adjusted Points			
Name	**Grid Northing (m)**	**Easting Grid (m)**	**Elevation (m)**
rover0810h_Q874	9227898,822	438475,268	28,318
rover07302_Q874	9221093,123	438981,928	206,811
rover07303_Q874	9221074,370	438544,724	218,855

3. Terrestrial Measurement with Total Station

Terrestrial measurements with a Total Station tool are performed to obtain angle and distance data at the observation points.

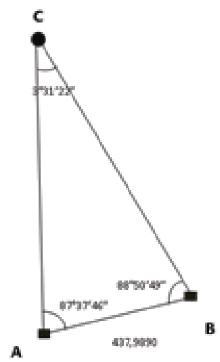

Figure 2: Point of observation 1.

Information:

A = observation point A on Diponegoro University campus, Semarang

B = observation point B in the Military Field of the Army of Central Java

C = observation point C in the area of the Great Mosque of Central Java, Semarang

S AB = Distance between Observation points A and B

βA βB βC = observation angle

4. Terrestrial Data Processing

   Processing of angular and distance data from terrestrial measurements is done in two ways, first calculations in the ellipsoid field using the Gauss Helmert calculation method and calculations in the flat area using the Least Square method.

   (a) Calculations in the field of ellipsoids (Gauss Helmert)

   In this research, the iteration calculation process and determination of its coordinates using the Gausz-Helmert calculation software made with visual basic 2008 and then converted to geocalc software which produces C point coordinates (438525.62609; 9228191.72472).

   (b) - Calculation in the flat area (least square)

   Coordinate calculation using leveling method required angle and distance data. In this study a minimum of 2 angular data and 1 distance data are needed. The C coordinate results from the least square calculation are C (438533,9265; 9228201.0260)

4.3. Research 2

The second study, observation points in the campus area of Diponegoro University, Tembalang, the Army Military Training Field, Central Java, and in the campus area of the University of Muhammadiyah Semarang, Semarang, Central Java.

1. GPS measurement

   GPS measurement is carried out to obtain position data for observation points for reference or as a reference data to be compared with the calculated data obtained from the calculation process of measurement data with Total Station. GPS measurements in this study use static methods.

2. GPS Data Processing

   After GPS measurements are done, the data is processed in order to obtain the coordinates of the observation points. GPS data processing is done using TOPCON tools software.

The results of the coordinates obtained from processing GPS data with this software are:

TABLE 2: Results UTM coordinates of Research 2.

Control Points			
Name	**Grid Northing (m)**	**Easting Grid (m)**	**Elevation (m)**
base0810d_T81S	9219941,183	435045,625	253,949
Adjusted Points			
Name	**Grid Northing (m)**	**Easting Grid (m)**	**Elevation (m)**
rover0810d_Q874	9221076,856	438539,870	218,829
rover0810e_Q874	9221093,126	438981,946	206,547
rover0810f_Q874	9223868,125	440580,900	49,118

3. Terrestrial Measurement with Total Station

   Terrestrial measurements with a Total Station tool are performed to obtain angle and distance data at the observation points.

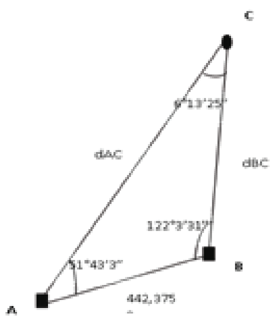

Figure 3: Point of Observation 2.

Information:

A = observation point A on Diponegoro University campus, Semarang

B = observation point B in the Military Field of the Army of Central Java

C = observation point C in the Semarang UNIMUS Campus area

S AB = Distance between Observation points A and B

βA βB βC = observation angle

4. Terrestrial Data Processing

   Processing of angular and distance data from terrestrial measurements is done in two ways, namely calculations in the ellipsoid field using the Gauss Helmert calculation method and calculations in the flat area using the Least Square method.

(a) Calculations in the field of ellipsoids (Gauss Helmert)

In this final project the iteration calculation process and determination of its coordinates using the Gausz-Helmert calculation software made with visual basic 2008 and then converted to geocalc software that produces C coordinates (440580.76631; 9223867.76662).

(b) Calculation in the flat area (least square)

Coordinate calculation using leveling method required angle and distance data. In this study a minimum of 2 angular data and 1 distance data are needed. The C coordinate resulting from the least square calculation is C (440581.0797; 9223868.5580).

(c) Deviation results of coordinate C

Table 3: Deviation of coordinate results C.

Method Comparison	Research 1		Research 2	
	ΔX (m)	ΔY (m)	ΔX (m)	ΔY (m)
Static GPS - Gauss-Helmert	50,358	292.903	0.134	0.358
Static GPS - Least Square	58.659	302,204	0.180	0.433

4.4. Accuracy calculation

i. Research 1

a. Accuracy of coordinate calculations in the ellipsoid field by the Gauss-Helmert method

Linear error:

$$\begin{aligned} D &= \sqrt{\Delta x^2 + \Delta y^2} \\ &= \sqrt{50,35809^2 + 292,90272^2} \\ &= 297,200m \end{aligned} \tag{2}$$

$$\begin{aligned} Accuracy &= \frac{D}{\sum \overline{d}} \\ &= \frac{297,2001692}{7123,7759} \\ &= \frac{1}{23,9696} \end{aligned} \tag{3}$$

b. Accuracy in calculating coordinates on a flat plane using the Least square method

Linear error use formula (2) and (3):

$$\begin{aligned} D &= \sqrt{58,65850^2 + 302,20400^2} \\ &= 307,8442418m \end{aligned} \tag{4}$$

$$\begin{aligned} Accuracy &= \frac{307,8442418}{7123,7759} \\ &= \frac{1}{23,1408} \end{aligned} \tag{5}$$

ii. Research 2

a. Accuracy of coordinate calculations in the ellipsoid field by the Gauss-Helmert method

Linear error use formula (2) and (3):

$$\begin{aligned} D &= \sqrt{0,13369^2 + 0,35838^2} \\ &= 0,3825039091m \end{aligned} \tag{6}$$

$$\begin{aligned} Accuracy &= \frac{0,3825039091}{3330,6931} \\ &= \frac{1}{8707,605441} \end{aligned} \tag{7}$$

b. Accuracy in calculating coordinates on a flat plane using the Least square method

Linear error use formula (2) and (3):

$$\begin{aligned} D &= \sqrt{0,17970^2 + 0,43300^2} \\ &= 0,4688082m \end{aligned} \tag{8}$$

$$\begin{aligned} Accuracy &= \frac{0,4688082}{3330,6931} \\ &= \frac{1}{7104,596549} \end{aligned} \tag{9}$$

4.5. Analysis of the contribution of Errors

1. Human factors Errors by human factors, among others, due to shooting errors.
2. Tool factor

   The instrument used for terrestrial measurements in this study is the SET630R total station with specifications:

(a) Angle Accuracy: 6 "

(b) Accuracy Distance Reflectorless: ± (8,10ppm x D) mm

(c) Correction coefficient for refraction: 0.142

(d) Natural Factors

Natural factors that must be taken into account are the effects of refraction and the curvature of the earth.

5. Conclusion

The conclusions obtained from the Analyst's research is the Accuracy of Reducing Triangulation of Taper Triangles with the base and angle distances measured by the Total Station are as follows:

1. The more acute the measurement angle, the accuracy obtained will get worse, this can be seen from research 1 with an angle of 3°31'22 "accuracy will be obtained 1/23,9696 for the ellipsoid (Gauss-Helmert) calculation method and accuracy 1/23,1408 in the flat plane calculation method (Least Square).

2. Based on research 1, measurements on small angular triangulation will get poor accuracy, while in study 2 measuring triangulation with large angles will get good accuracy.

3. From the results of the comparison of accuracy in determining the definitive coordinate values generated through calculations in the ellipsoid field with the Gauss-Helmert method, the definitive value is closer to the reference value measured by the static GPS method rather than determining the definitive coordinates produced through calculations on a flat plane using the method Least Square.

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