CE 331A: Report for Lab project

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Course Code	**CE331A**	
Course Title	**Geo-Informatics**	
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Evaluation Remarks	**Criteria**	**Marks**
	Overall comprehension	
	Content	
	Correctness	
	Completeness	
	Writing skills	
Evaluators Name		

Abstract

Monday Batch, Group 2 mapped the area around the faculty building and the DOAA Canteen as part of their lab project. The team spent the allotted five weeks performing reconnaissance to established control points, measuring side lengths and interior angles for the closed traverse, determining elevation for the established control points and using GNSS to determine global coordinates of the control points in the UTM (Universal Transverse Mercator) coordinate system, and mapping features of the area to prepare a two-dimensional of the entire area allotted using the QGIS software.

LITERATURE REVIEW

Since the dawn of civilization, many millennia ago, one of the most significant achievements of humanity has been the creation of maps. Since then, both the theory and practice of surveying have advanced significantly, allowing for the production of maps with unprecedented precision with the use of satellites and other ground-based sensors.
The goal of this endeavor was to introduce students to the fundamentals of modern mapping techniques for tiny regions, including traversing, GNSS surveying, and feature mapping with total stations, all of which boast millimeter-level accuracy. Each week of the six-week project, we were tasked with implementing a different core principle of cartography.

The first week involved Reconnaissance and the establishment of control points. In the surveying process, this is the first and most crucial stage. Site conditions and local infrastructure availability must be investigated, and control points must be set up accordingly (Merriam and Anderson, 1942; Cooper, 1987). For topographical surveying, supplemental point control, or dimensional control on-site, a control network must be established, which consists of a sequence of points or places known as control points (Yimin, 2006; Starek et al., 2014). The mission for the following week was to take measurements of the near traverse's side lengths and interior angles to determine the area's shape (Ehigiator and Ehigiator).
The control points' elevation in the area to be mapped was then determined using an auto-leveling task scheduled for the following week. The creation of contour lines on a map is a primary application of this method (Ashraf and Ahmad, 2008; Zhao et al., 2008; Shaotang and Jiechen, 2014). After completing these groundwork steps, we used the initial control point to locate and make a Bowditch correction to the area's local coordinates (Jolly, 1938; Biesheuvel, 1958). We determined the adjusted global coordinates of all the control points by using the GNSS instruments to get the original global coordinates of specific points and then applying Similarity Transformations to those coordinates (Taussky and Zassenhaus, 1959; Neitzel, 2010). Last but not least, in the final weeks of the project, we mapped different types such as trees, poles, buildings, the fountain, etc.

OBJECTIVES

Some of the main goals of the project are:

- The goal is to set up a closed traverse that allows for maximal feature capture while still allowing for maximum inter-visibility.
- Take local coordinate measurements of side lengths and interior angles, then use Bowditch's rule to fine-tune the entire traverse.
- To use Auto-Level to level the area.
- The purpose of the GNSS receivers is to retrieve the global coordinates of a small number of control points, and the similarity transformation is used to convert the local coordinate system into the global coordinate system.
- Establishing Total Station control sites and taking feature measurements.
- To compile all of the collected data into a two-dimensional map.

INTRODUCTION

Concepts used and words related to them

2.2.1 Reconnaissance

In military operations, reconnaissance or scouting is the act of looking around outside of an area where friendly forces are stationed to learn about the area's natural features and other activities. It is the first and most important step in the surveying process. It involves looking at how the site is set up and what kinds of infrastructure are in the area. Based on this, control points are set up.

2.2.2. Traverse

In the field of surveying, the traverse is a way to set up control networks. Traverse networks are made by putting survey stations along a line or travel path and then using the last point that was surveyed as a base to look at the next point. There are many benefits to traversing networks, including

- There will be less of a need for preparation and scouting.
- The traverse can take on any shape, allowing it to adapt to a wide variety of terrains, unlike some other systems that may require the survey to be conducted along a strict polygon shape.
- Unlike other survey networks, where a large number of angular and linear observations must be made and considered, this one only requires a small number of observations at each station.
- Traverse networks are free of the strength of figure considerations that happen in triangular systems.
- As the traverse is done, the scale error does not add up. Readers can also cut down on azimuth swing errors by making the distance between stations bigger.

2.2.3. Levelling Process

The main idea behind leveling is to find the distance between a level line that goes through a known elevation point (B.M.) and one that goes through an unknown point (whose elevation is required to be determined). It helps pipe transport engineers make sure that the land has the right slope to make it easy for water and other liquids to flow through the pipe. It also helps contractors make a flat surface on which to build the building. Errors in levelling are of the following types:

1. Instrumental Errors
2. Personal Errors
3. Errors due to natural causes

2.2.4. Distribution of closing error in Levelling process

Closing error (e) can be distributed to each station by this expression

$$C = -e^* \frac{d}{D}$$

Where
d= distance of a station from BM
D= total distance travelled

2.2.5 Total Station

A total station is an electronic and optical tool used for building construction and surveying. It is an electronic transit theodolite with electronic distance measurement (EDM) to measure both vertical and horizontal angles as well as the slope distance from the instrument to a certain point and an onboard computer to collect data and do triangulation.

2.2.6. Systems of Bearing

- ***Whole circle Bearing****:* It is used to measure land with a prismatic compass, and it was also used in this lab experiment. In this method, the north is used as a point of reference, and angles are measured in a clockwise direction. Angles can be measured from 0 degrees to 360 degrees.
- ***Quadrant Bearing****: With this method, you can use either north or south as a point of reference. Also, the direction of measuring an angle can be either clockwise or counterclockwise. The measured angles must be between 0 degrees and 90 degrees, so the reference direction or measurement sense is flexible.*

Quadrant in which bearing lies	*Conversion relation*
NE	$\alpha = \theta$
SE	$\alpha = 180° - \theta$
SW	$\alpha = \theta - 180°$
NW	$\alpha = 360° - \theta$

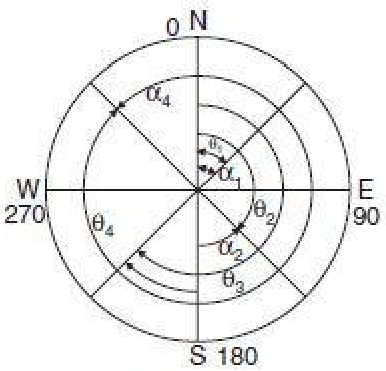

Fig. 13.4

Figure 1: WCB and Quadrant Bearing Conversion formulae

2.2.7. Global Navigation Satellite System (GNSS)

Global Navigation Satellite System, or GNSS, is the standard name for all satellite navigation systems that give a geospatial position anywhere in the world. The whole system is made up of 24 satellites that orbit the earth, and at least 4 of them are needed for positioning.

2.2.8. Bowditch Rule

The Bowditch Rule is given by:

$$\delta E_i = \frac{\Delta' E}{\sum_{i=1}^{n} L_i} \times L_i = K_1 \times L_i$$

and

$$\delta N_i = \frac{\Delta' N}{\sum_{i=1}^{n} L_i} \times L_i = K_2 \times L_i$$

Where,

$\Delta'E$, $\Delta'n$ = the coordinate misclosure (constant)

δE_i, δN_i = the coordinate corrections

ΣL_i = the sum of the lengths of the traverse (constant)

L_i = the horizontal length of the i^{th} traverse leg

K_1, K_2 = the resultant constants

2.2.9. Similarity Transformation

The data is scaled, turned, and moved by the similarity transformation. It won't scale the axes on its own, and it won't cause any skew. It keeps the proportions of the transformed features, which is important if you want to keep the shape of the features. The similarity transform function is

x' = Ax + By + Cy' = -Bx + Ay + F

where

A = s * cos t

B = s * sin t

C = translation in the x direction

F = translation in the y direction

and

s = scale change (same in x and y directions)

t = rotation angle, measured counter-clockwise from the x-axis

A similarity transformation requires a minimum of two displacement links. However, three or more links are needed to produce a root mean square (RMS) error.

Equipment/Tools/software Used

- Paint
- Total Station
- Retroreflector
- GNSS Receiver
- Auto Level
- Levelling Staff
- Pegs
- QGIS Software
- Ms-Excel for calculations

METHODOLOGY/EXPERIMENT

Week 1

- Performed Reconnaissance of the assigned area to set up control points, taking into account how visible the previous and next points are from the current point and how easily the current point can be disturbed.
- Set up a total of 5 control points for the whole area to be mapped, and painted them to make them permanent and easy to find in the future.

Week 2

- Total Station was used to measure the distances between the set control points (the lengths of the sides) and the angles between two sides that were next to each other.
- Auto-level through the Height of the Instrument method was used to move the level from the benchmark (BM) in the GI lab to the control points that had already been set up.

Week 3

- Traversing through Total Station is done. All of the side distances and interior angles for the control network have been measured.
- Completed leveling of all established control points.
- Using a GNSS receiver, the global coordinates of 4 of the 5 control points were found.

Week 4

- Changed the control network's overall angle misclosure.
- By adjusting the angles and measuring the side lengths, I was able to obtain the local coordinates of all the spots. I used one of the side lengths in the north direction.
- Using Bowditch's rule, I corrected the latitude and longitude of every control point to remove the inaccuracy.
- Utilized data from a GNSS receiver at three different locations and performed a similarity transformation to convert coordinates from the local system to the Universal Transverse Mercator (UTM) system.
- Using a Total Station, we have begun mapping features and have thus far covered 1 of 5 sites.

Week 5

- All known control points have been mapped out in full detail.

Week 6

- Use QGIS to make the map's preparations.
- I have finished all of the tasks that needed to be done after returning from a field trip.

CALCULATIONS/MEASUREMENTS

- **Balancing the angles**
  From each of the Fig.1 control sites, we measured the lengths of the sides and the included angles using the Total Station.

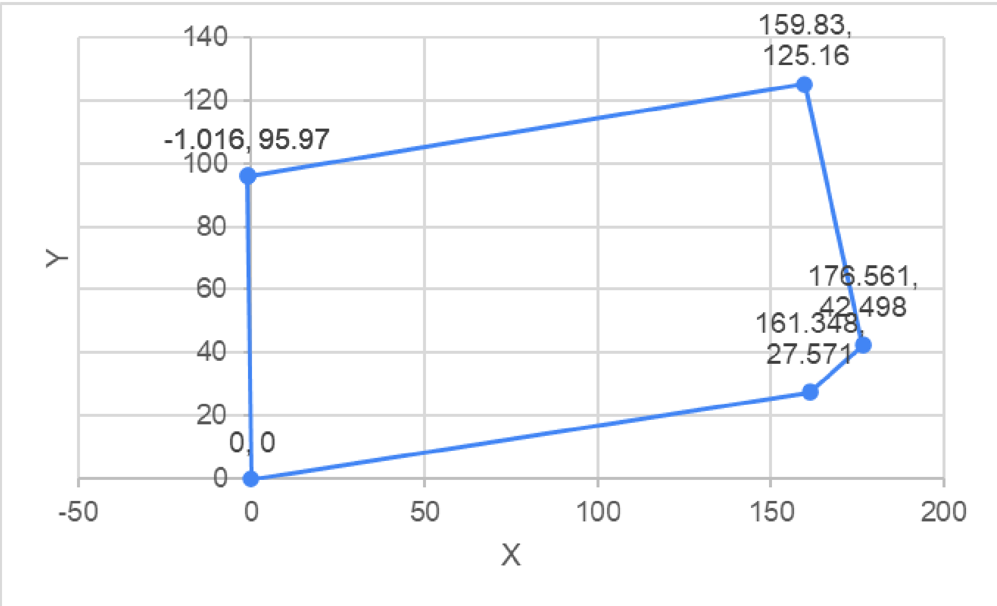

Figure 2: Established Control Network

The calculation which was performed is tabulated below- Balancing angles in the polygon

Name of the angle	Measured Value
∠A	97°47’29”
∠B	91°08’08”
∠C	122°28’16”
∠D	145°46’15”
∠E	82°49’48”

- **Adjusting heights**
  The heights were adjusted using the following Bowditch's Rule:

$$C = \; - e\frac{d}{D}$$

Where,
C = correction to each RL value
e = closing error
d= distance of a station from BM
D= total distance traveled

Station	B.S. (in m)	F.S. (in m)	R.L. (in m)	Corrected RL (in m)
BM	1.188		128.409	128.409
E	1.559	1.442	128.155	128.157
A	1.442	1.858	127.856	127.855
1	1.495	1.318	127.980	127.979
B	1.558	1.583	127.892	127.890
C	1.605	1.695	127.755	127.753
D	1.941	1.582	127.778	127.775
2	1.558	1.610	128.109	128.106
E	1.711	1.505	128.162	128.157
BM		1.460	128.413	128.409

Misclosure (M) = Last RL – First RL = 128.413 – 128.409 = 0.004 m = 4 mm

- **Finding out the Whole Circle Bearings**
  The North direction was thought to be along the EA line. Then, the traverse's whole circle bearing was determined for each line that connected the previously defined control points. The equivalent is listed in the table below.

Sides	Whole Circle Bearings Angle
AB	80°12’31’’
BC	168°25’02’’

CD	225°56’46’’
DE	260°10’31’’
EA	00°00’00’’

- **Adjustment of misclosure using Bowditch’s Rule and calculation of local co-ordinates**
  Latitude and Departure were determined using the WCBs collected in the prior phase and then modified using Bowditch's approach. (All length in m)

Side	Whole Circle Bearing			Length [d]	Latitude [dcosα]	Departure [dsinα]	Corrections		Balanced	
	Angle [α]	cosα	sinα				Latitude	Departure	Latitude	Departure
AB	80°12’31’’	0.173	0.984	165.111	28.671	162.602	0.582	-1.756	29.253	160.846
BC	168°25’02’’	-0.978	0.207	84.816	-82.962	17.634	0.299	-0.902	-82.662	16.731
CD	225°56’46’’	-0.707	-0.707	21.216	-15.002	-15.002	0.074	-0.211	-14.927	-15.213
DE	260°10’31’’	-0.173	-0.984	162.073	-28.143	-159.610	0.571	-1.723	-27.571	-161.333
EA	00°00’00”	1.000	0.000	95.570	95.570	0.000	0.337	-1.016	95.907	-1.016
			Σ	528.786	-1.866	5.624			0.000	0.000

Next, using the obtained Latitudes and Departures, the local coordinates of all fixed control sites were determined. We used point E as the coordinate origin (0,0) and the line EA as the y-axis. The z-coordinate was determined using the revised heights from the Auto-Level measurements.

Points	Local Co-ordinates		
	x	y	z
A	-1.016	95.970	127.855
B	159.830	125.160	127.890
C	176.561	42.498	127.753
D	161.348	27.571	127.775
E	0.000	0.000	128.157

- **Transformation of co-ordinate system using Similarity Transformation**
  Following equations were used for similarity transformation from local to WGS84/UTM co-ordinates:

$$E = ax + by + c$$
$$N = -bx + ay + d$$

Where,
E: Easting of the point in UTM co-ordinates
N: Northing of the point in UTM co-ordinates
a, b, c, d: constants of transformation
The value of constants of transformation was determined using Least Squares method using Northing and Easting values that were retrieved from Baseline Report of GNSS receiver using following equations:

$$E_i = ax_i + by_i + c$$
$$N_i = -bx_i + ay_i + d$$

$$AX_a = L_b$$

$$A = \left[x_5\, y_5 - y_5\, x_5\, x_6\, y_6\ 1\,0\,0\,1\,1\,0 - y_6\, x_6\, x_{10}\, y_{10} - y_{10}\, x_{10}\ 0\,1\,1\,0\,0\,1\right]\ X_a = [a\, b\ c\, d\ ]$$

$$L_b = \left[N_5\, E_5\ N_6\, E_6\ N_{10}\, E_{10}\ \right]$$

$$X_a = \left(A^T A\right)^{-1}\left(A^T L_b\right)$$

After transformation, Global co-ordinates that were calculated are tabulated below:

Points	x	y	z	Northing	Easting
A	-1.016	95.970	127.855	2932823.433	423474.424
B	159.830	125.160	127.890	2932825.628	423639.439
C	176.561	42.498	127.753	2932740.918	423642.263
D	161.348	27.571	127.775	2932728.953	423624.722
E	0.000	0.000	128.157	2932728.636	423462.722

Results

Below is a map that was created by combining several different sets of data:

Monday Group 2

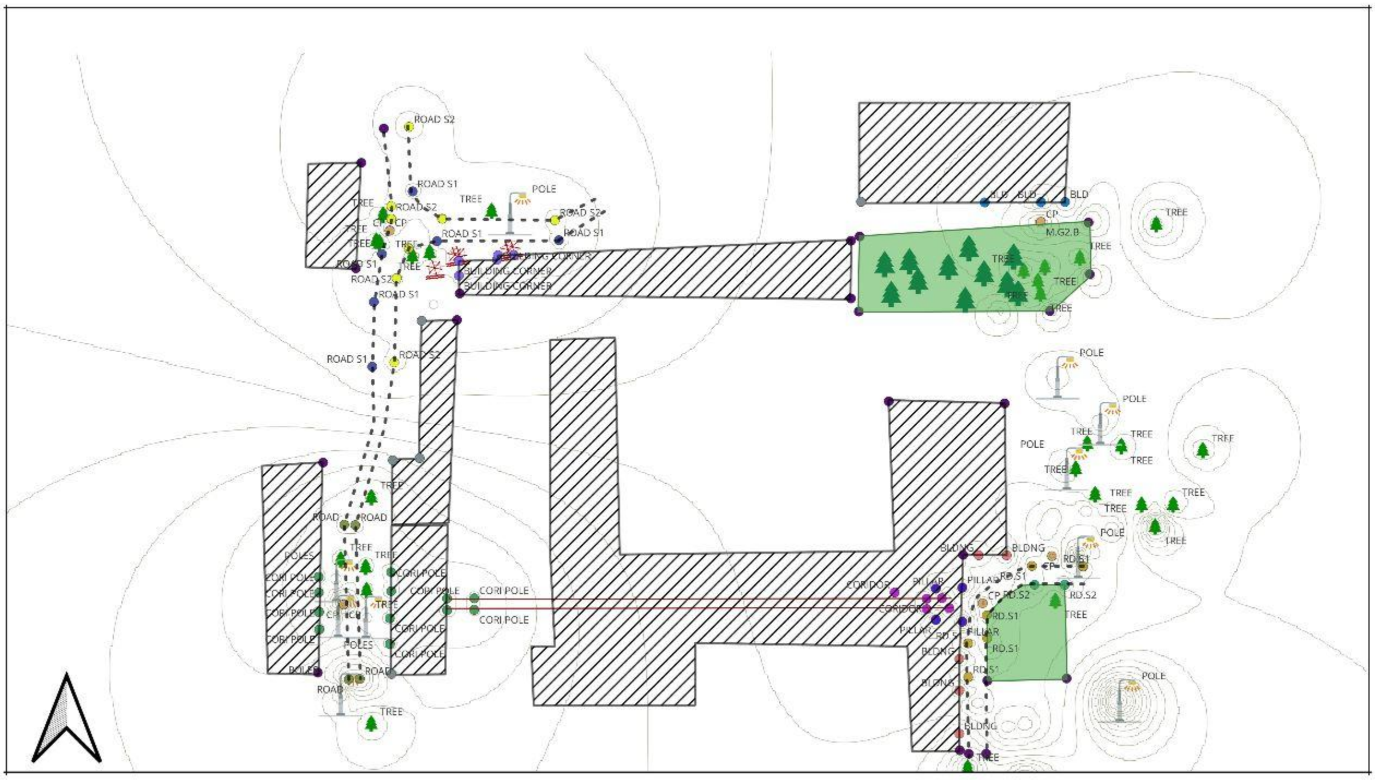

Figure 3: Map

Scale 1: 153299936

Road

Parks

Buildings

Light Pole

TREE

CONCLUSION

The lab exercise gave students practical experience in the steps involved in conducting a Geodetic Survey and in the following cartographic representation of the geographical data collected.

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