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EVALUATION OF ACCURACY GPS AND AUTOMATIC LEVEL INSTRUMENTS IN TOPOGRAPHIC SURVEYING

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Abstract- The goal of the research was to compare a GPS and an automatic level instrument in computing elevations which has been practiced in the district of the Technical Institute of Anbar. The result of this work is shown that the convenient work by GPS system in surveying. In addition to this, a lot of researches were done about contour map creation and these studies depended on different data resources and methods. But those studies did not compare the resulted data of the mentioned instruments. The modern methods and equipment used in the survey, such as the GPS receiver, which have advantages and characteristics differ from that in traditional method like the automatic level device. Finally, the accuracy of the results also investigated in line with the resolution of digital elevation model and the slope of the topography. The findings of the study show the effect of the source data, resolution and ground control point distribution.

Keywords: Contour Map, DEM, GIS, GPS, TIN.

1. INTRODUCTION

Position determination with saving time and higher accuracy is an important subject in surveying. The cost effectiveness of traditional leveling to provide good accuracies is good, but this work only in small study areas [1]. After a few decades, in order to increase the accuracy of a geoid calculation, many efforts were realized in developing technologies and procedures [2]. Dependable information obtained when deals with this technique in short time. Currently, GPS represent the most popular technology in topographic and Geodetic surveying.

The coordinates for points obtained by observing two or three fixed stations in space, these coordinates represented as a geographic system or in the UTM system as (*X*, *Y* and *Z*) [3]. Many applications in surveying tend to use the development techniques like GPS technique in the evaluation of data collected in different fields of survey [1]. There are three reasons effects of error in GPS navigation and accuracy positioning: error of signal delay by troposphere, error of satellite orbits and ionosphere delay [4]. Assessment of GPS and the automatic leveling device shows statistically well-matched results [5].

Also, the cost saves 40% with GPS methods, it helps to reduce the number of staff and finding dependable coordinates [6]. The getting of accurate position with saving time and speed information and navigation all these done by using GPS [7]. According to the study, geographic coordinates of points are confident in GPS while the elevation obtained through traditional surveying is uncertain. Finally, this study tries to prove the accuracy of GPS comparing with another method of measurement to create contour map.

2. PROBLEM AND OBJECTIVE OF STUDY

The control points are the basis for any projection coordinates on the earth, when these points established in the field by using advanced instruments within higher accuracy and record the references for those points in anticipation of their loss. The instrument used to get up the control points is a DGPS (differential Global Positioning System), Total station, when visiting the Municipal Department, we found that there is a lack of information and the unavailability of ground control points due to the unavailability of the above-mentioned devices. This forced the researcher to request information from sources in the private sector because of their modern equipment that is not available in government departments. In our study these important points are almost non-existent.

The traditional method using the Automatic level instrument in computing the elevation and GPS method will greatly contribute to detect more clarity about the nature of the Earth's surface of the study area. Finally, research goal is to create a digital elevation model from different information sources and prepare digital topographic maps from various information sources, which can be used in the future in many studies because this study provided information such as ground control points, the digital map, and the reliability of the work with the global positioning system and leveling device.

3. CASE STUDY

The study area is a city located in eastern Iraq, on the side of the Tigris River, about 160 kilometers (99 miles) southeast of Baghdad. It's placed on Iraq map at the geographic coordinates Latitude: 32 29' 51", Longitude: 45 49' 45", As shown in following Figure 1.

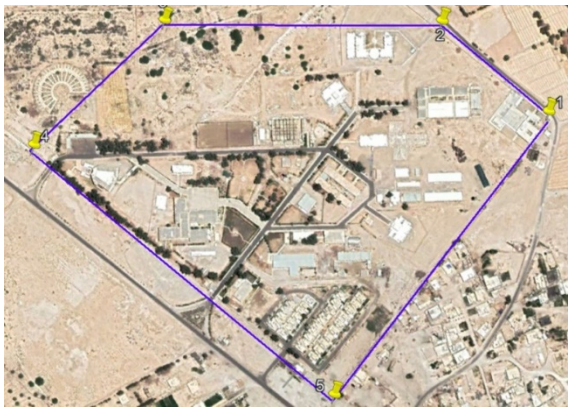

Figure 1. Area of interest borders

Table 1. Coordinates of study area

Point	Easting (m)	Northing (m)
1	376387.08	3699583.94
2	376229.19	3699719.96
3	375815.99	3699725.26
4	375618.38	3699542.97
5	376062.49	3699167.60

4. LITERATURE REVIEW

1) Accuracies of Global Positioning system and Total Station (TS) were examined in GIS environment. This case study showed that an inaccurate survey can result cost estimates up to 27%. The evaluation of two methods with GPS and TS showed that RTK-GPS (Real Time Kinematic, Global Positioning System): It's application to correct common errors in surveying depending on comparison the measurements of signal with measurements of references station, founded surveys are not only practical and fast, but also yield more accurate topographic maps for design purposes [8].

2) Measurement the distances directly instead of establish the measurement for long time in field with comparing the precision of GPS and differential GPS (DGPS), which explain the performance of DGPS over GPS, the difference between GPS and DGPS when horizontal and vertical accuracies are considered [9].

3) To monitor the construction of tower by using GNSS (Global Navigation Satellite System) receivers with a total station, two measurements of methods were used, first one was depending on determining the position of monitoring points by total station integrated with GNSS receiver. The second one was to determine the direction and distance to locate the monitoring points by using two GNSS antenna and total station coupled with prism reflectors. The result is compared with traditional methods of measurements and showed this method is suitable for monitoring tall construction buildings [10].

5. DATA AND SOFTWARE

5.1. Data Used

The types of data used in this research are divided into two types: first one called non-spatial data to describes the study area and to facilitate the process of DEM production, characteristics of this data are satellite image (Quick Bird), spatial resolution (0.6-0.7 meter) belong 2009, second type is spatial data which consists of Coordinates and Elevations taken by GPS (Garmin 62S) and elevations calculated by Automatic level instrument (Leica brand).

5.2. Software Used

The software used is ARC GIS (Version 10.2), this program consists of three applications: ARC MAP, ARC Catalog and ARC toolbox, these applications facilitate the process of creating contour lines and DEM production. The second program is Microsoft office (word and excel) which help us to create tables which entered into the ARC GIS software.

6. RESEARCH METHODOLOGY

The main focus of this study is to prepare topographic map and DEM creation and assess accuracy of them as shown in (Figure 2).

6.1. Work Flow

a) Capture points with their coordinates and elevations by using a GPS receiver and automatic level instrument.
b) The data prepared (elevations and coordinates) entered into the ARC GIS software as an excel file to Creating a contour map according to elevations computed by level instrument and elevations collected by the GPS receiver, contour interval entered is the same for both devices.
c) With helps of the same excel file to create DEM (digital elevation model).
d) Accuracy of the DEMs created from GPS and automatic level data is evaluated.

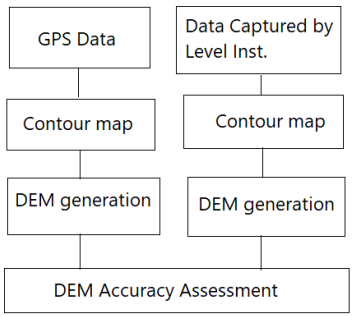

Figure 2. Research methodology

6.2. Data Collection

Data are collected by using a GPS receiver (Garmin 62S). Through this process the points are selected randomly in the study area, the coordinates and elevations were taken for each point with specific times of observation. GPS is used to decrease distortions and to increase the positional accuracy of these points [11].

The ellipse shape is as close as possible to represent the earth's surface at the global level, so that the difference between it and the geoid vary from place to place on the surface of the earth. When adopting a certain Ellipsoid, there will be the smallest difference between it and geoid, so each country tries to modify its reference or reposition in order to achieve this goal. The reference

resulted from that modification is called geodetic datum or local datum, simply the global ellipsoid modified to be suitable for a specific country in order to give the real representation of the earth's surface.

6.3. Field Verification (Ground Truth)

The information that is related to the location called Ground Truth. The image data necessary to link with real features and materials on the ground. The preliminary interpreted maps were taken to the ground for verification. Doubtful areas were checked in the field and modifications were done as per ground verification. GPS points were stored in the form of latitudes and longitudes. Various photographs of the study area, including structures and LU/LC feature such as scrubland, plantations, public-semipublic areas etc. were also clicked.

After coming back from ground truth, all the GPS points were transferred to computer using GARMIN software. After preparing DBF file of GPS points it was then converted to a point shapefile in ArcMap software. After that, shapefile opened on the geodatabase. Then Correction was done.

6.4. Georeferencing

The process of assigning coordinates from map to image satellite called Georeferencing. The image data should be projected to accept plane and referenced to suitable coordinate system. Rectification, means the map and their projection are associated.

6.5. Contour Map

The elevations entered into Arc Map with their coordinates in order to create a contour map with respect to interval contour, the interval contour depends on many elements such as nature of the earth's surface, the purpose of the map, accuracy required on the map and the scale. Simply the interval contour increased on the plane or flat surface and decreased in the sinuous surface.

7. RESULTS AND DISCUSSIONS

7.1. Results

The creation of DEM depends on altitude and spatial resolution. The measurement unit of digital image is a pixel which represents the ground features on the image. 25 points were selected to check their elevations in the study area. The contour lines which are linked elevations and position of points that taken by GPS and automatic level respectively are displayed in Figures 3 and 4.

7.2. Accuracy Assessment and Contour Map Creation

The dimension of point (X, Y) refers to the accuracy of that point and called spatial [11]. For the evaluation of DEM generated, the known points on the ground are used as GCPs as well as elevations are used for this study. Figure 3 explains how contour lines are created depends on their heights from mean sea level were taken by GPS receiver with contour interval one meter. The contour interval takes into account the nature of earth's surface, purpose of map and scale used to produce maps.

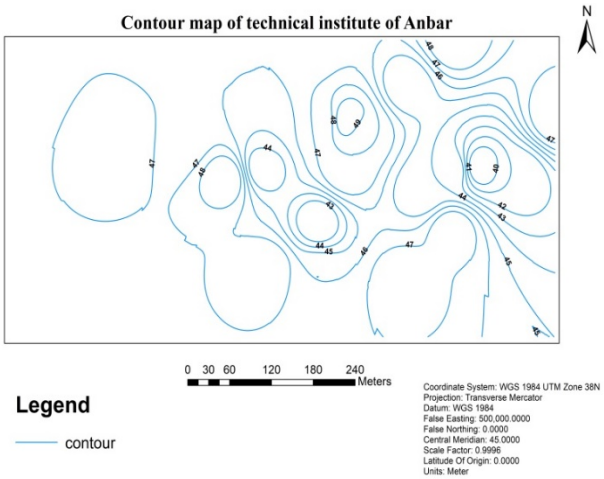

Figure 3. Contour map (AOI within elevations by GPS receiver)

In Figure 4 contour map is created depending on elevations computed in height of instrument method (H.I) by using an automatic level instrument, the map was Created with same contour interval (1 meter). The next step it is to create DEM file by converting the contour map to TIN (Triangular Irregular Network).

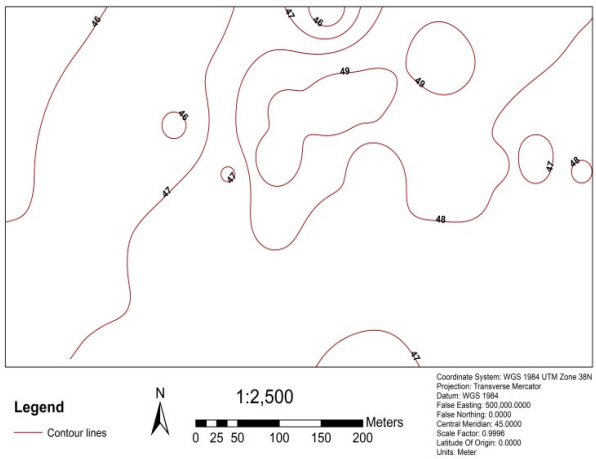

Figure 4. Contour map (AOI within elevations by automatic level)

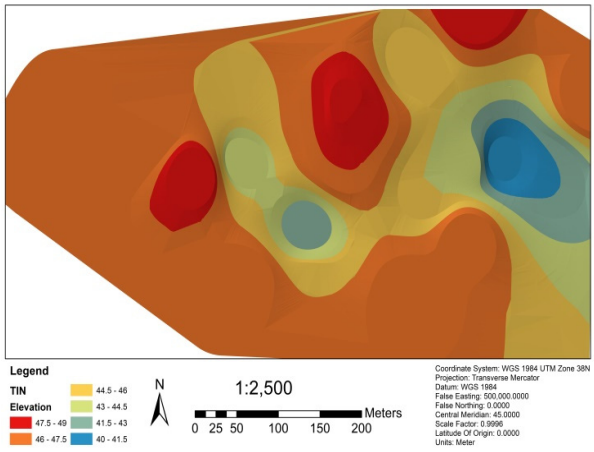

Figure 5. TIN show elevations taken by GPS

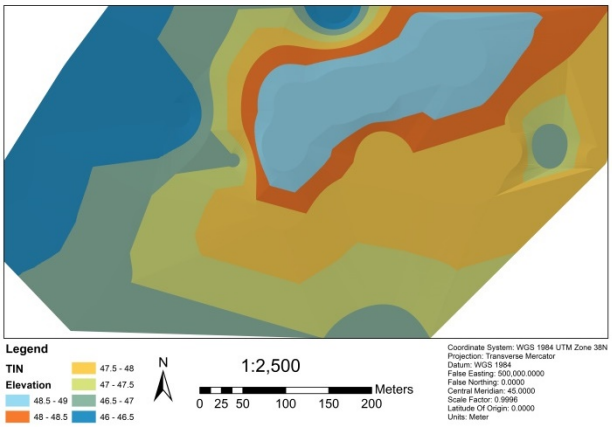

Figure 6. TIN show elevations of automatic level data

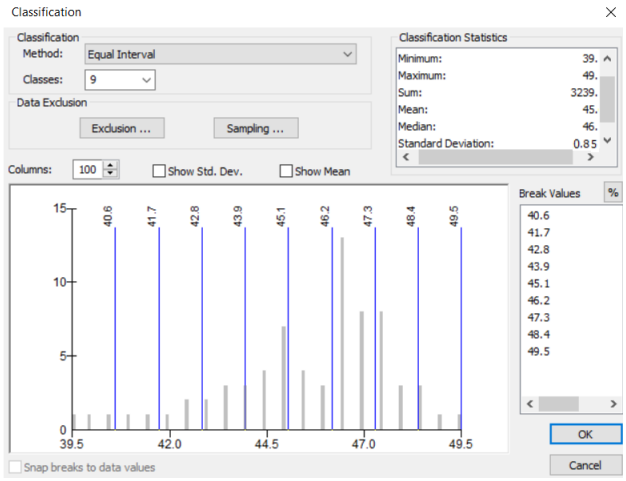

Figure 7. Standard deviation and mean of GPS data

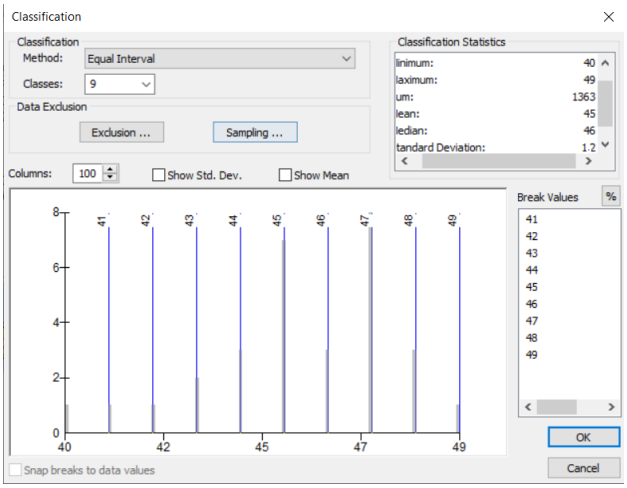

Figure 8. Standard deviation and mean of automatic level data

Figures 7 and 8 show the standard deviation for data which represent data accuracy variation, consequently higher value means the data tends to be separated out of range and less reliable and vice versa. This conclusion leads us to the preference of the results issued by global positioning system. Table 2 explains the results of reduced level by two devices. Elevations collected by GPS receiver which are getting it directly, and elevations computed by an Automatic level instrument.

Table 2. Comparison results of two sets of data

P	X (m)	Y (m)	R.L by GPS	R.L. by Automatic level	Difference between two methods of measurements
1	3699359	375901	48	47.995	0.005
2	3699350	375973	46	47.995	1.995
3	3699422	375973	44	47.513	3.513
4	3699491	376014	48	47.118	0.882
5	3699482	376262	46	48.073	2.073
6	3699555	376020	50	49.978	0.022
7	3699553	375972	47	49.838	2.838
8	3699600	376100	47	49.678	2.678
9	3699548	375909	47	49.278	2.278
10	3699465	376124	46	48.200	2.2
11	3699490	376166	47	48.310	1.31
12	3699494	376206	45	47.422	2.422
13	3699540	376040	48	48.123	0.123
14	3699493	375895	47	49.014	2.014
15	3699479	375842	49	46.915	2.085
16	3699531	375778	46	45.847	0.153
17	3699536	375702	48	46.185	1.815
18	3699660	376167	49	48.512	0.488
19	3699648	375782	46	45.867	0.133
20	3699637	375530	46	45.554	0.446
21	3699344	376098	48	47.231	0.769
22	3699559	376314	48	47.852	0.148
23	3699657	375960	46	45.378	0.622
24	3699271	376003	47	46.058	0.942
25	3699411	376166	48	47.902	0.098

7.3. Discussions

The result of this study is to show the ability and effectiveness of GIS in creating contour map and then produce a digital elevation model according to varied sources of date and compare the accuracy of them.

The main discoveries of the research show that the modern techniques of measurements and software made the possibility of dealing with geographic data networks and management system (GDBS) very efficiently. It can be produced DEM by analysis of statistical data by using mathematical tools, this contributes to a visual interpretation of an image and get information of datasets with high accuracy. Spatial data used can be processed and storing to get the information by using GIS and RS techniques under the term "Geodatabase" [12]. The integrated of space technology applications with field measurement which impact to result high accuracy [13]. The Accuracy of GPS receiver depends on some factors such as time of signal transition, imperfect orbits, skills of observer. All these factors should be taken into account. By using Automatic level instrument to measure the height difference between points, then compute their elevations depending on the benchmark (it's a point known position and location), error of measurement on the rod and quality tools used in measurement (rode, level instrument, tape measurement) can be affected on results. Data collected by each device (GPS and level instrument) entered into the software (ARC GIS) for processing and create contour map. In this study the satellite image was used to show the location of points on the earth and give more to give the work flexibility and reliability and to obtain accurate results, in addition to the visual interpretation of the image, which contributes to the delivery of the idea to users.

8. CONCLUSIONS

The survey data were used to create topographic representations with higher accuracy. It should be notice how to use the same contour interval for both contour maps. This study revealed the following.

- As a result, in a Figures 3 and 4, the number of contour lines using the GPS receiver is 25, while the number of contour lines in Automatic level instrument was only 12 lines for the same contour interval. This led to the short distance between contour lines resulted in GPS and vice versa.
- According to the characteristics of contours, closely spaced contour indicates to steep ground and the increasing of contour lines meaning high accuracy [14]. So, this led to the GPS receiver is more accurate than automatic level.
- The standard deviation with GPS data and an Automatic level was 0.85 and 1.2, respectively, as shown in Figures 7 and 8, the decreasing value in standard deviation indicates that the data are homogeneous and more accurate and vice versa.

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