Evaluation of the Use of Remote Sensing Techniques for Highway Alignment Layout

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ABSTRACT

The present research represents the ability of using the remote sensing techniques in highway engineering field throughout the evaluation process for road alignment that is considered in the study (Emam–Waise detour). This road lies between Al-Mukdadiyah and Khaneqeen towns connecting Al-Sa'adyah and Ibraheem Al-Somayda'ay villages along that alignment in the eastern part of Iraq.

The research idea focuses on an evaluation process for the alignment in reconnaissance and preliminary planning stages depending on the compression process between the used conventional method which represents field survey operations and the new method which depends on remote sensing techniques and *Digital Terrain Model design (DTM)*, through using of the most important programs in *Geographical Information System (GIS)*. A Landsat (**Thematic Mappar**) image taken for the study area is used in the analytical part of the work after some pre-processing for the image , including the enhancement process that helps us in data collection steps, especially in the determination of Ground Control Points (GCPs) which are distributed in the region.

The study is also concerned with dividing the work into two main parts: **The first** one represents road field survey measurements that lie on the road centerline and sides (5m distance from each side). **The second** part of the work represents a (DTM) design, which gives three- dimensions (E, N, H) for each point in the region.

A method for digital terrain model design is adopted, it is called (scanned contour lines) method, which depends on the topographic map of the study area of (1:100.000) scale and (10 m) contour interval , also using GIS program (Arc view, ver.3.1).

A comparative study was conducted between the field measured coordinates and the corresponding coordinates extracted from digital model through plotting a longitudinal profile for field and DTM measurements together having the same scale, based on differences of heights. The study shows that the coincidence ratio between the two methods is 82%. After correcting the value of the contour interval of the base map that contains an error in contour interval values, the coincidence ratio between the two methods was increased to 95%.

KEYWORDS: Remote sensing, Highway engineering.

INTRODUCTION

The aim of this work is to make a right evaluation for (Emam-Waise) road alignment, especially in the first planning stages represented by reconnaissance stage and preliminery survey for road fixing. This evaluation will be made through a perfect comparison between traditional methods and digital methods for preliminary planning .

• Road's field survey stage.
• DTM design stage.

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Figure (1): An image of 1/100,000 scale map of Khaneqeen.

Study Area Description

The study area is described through the following conditions:

- It lies between Al-Mukdadiyah and Khaneqeen towns. The road of interest called (Emam-Waise detour) starts from Al-Sa'adiyah intersection and ends at Ibraheem Al-Somayda'ay street with a length of (16.100 km). The area which covers about (494.6 km^2) extends between latitudes (34^o 00-34^o 13, north) and longitude (45^o 06-45^o 18, east). The location of the study area is shown in Fig. (1) and Fig. (2); also in appendices A, B and C.
- Valleys and mountains are the most active forms of land cover in the region due to the high slopes in this region.
- The soil type is selty and had been carried by Dyalah River and resulted from the erosion and transmission of river deposits. Also, the texture of soil profile is different from one place to another depending on the distance near or away from water streams.

Al-Sa'adiyah Intersection

To Ibraheem Al-Somayda'ay Village

Figure (2): Study area location.

ROAD FIELD SURVEY

The main aims of this study is to determine the profile and cross-sections and also locate the curves of the road from Al-Sa’adyah-Khaneqeen intersection to Ibraheem Al-Somayda’ay street, with a length of (16.100 km), in three dimensions (E, N, H). Accordingly, a methodology is used for this work to determine the type of the instruments that would be used in the work.

The work is done in steps as follows.

Field Reconnaissance

At first, reconnaissance of the road was made during a detailed study for the enhancement **Landsat/TM** image for the study area **Khaneqeen**, and coincidence was achieved between information obtained from it and the important information obtained from a (1/100,000) scale map for the same area.

All this information must coincide with the actual features in the field. So, the important step was the searching for the Ground Control Points **(GCPs)** available in the area that has been carried out, and found as a result from that searching three **GCPs** holding the following numbers **(15019, 15016, 15024).**

After these points were found on the map, a check was made for their locations in the field, and the following was found:

- The point (15024) exists with its direction,
- The point (15019) exists without its direction,
- The point (15016) was not reached because it was located outside the working area.

Accordingly, the first two points were considered in the work. The coordinates of both points were illustrated in Table (1).

Table 1. Coordinates of the considered ground control points.

P.N	Easting (E)	Northing (N)	Azimuth	Dist. in (m)	Elv. In(m)
15024	525241.55	3791957.10	127°24 05.39	679.30	286.7
15019	523252.15	3777244.13	292° 49 11.04	608.50 0	256.1

In this step, also a check for the precise level lines that exist in the work location have been carried out, and as is known, these lines contain numbered points having known elevations. The point (54) is considered located on the line (30) along the street from Al-Sa'adiyah to Khaneqeen, because of its close position to the starting point. The elevation of the BM (30-54) was found equal to (214.3655m).

The readings of all points in profile and cross-section are listed in Table (2).

Table 2. Elevation values of the fixed points of the reading in the field.

Sta.	Measured Elevation (m)		
	Left	C	Right
0+00	-	174.603	-
1+00	171.812	171.756	171.603
2+00	169.558	169.718	169.868
3+00	167.753	167.951	168.168
4+00	166.740	166.855	167.090
5+00	165.990	166.120	166.400
6+00	165.353	165.500	165.745
7+00	164.795	164.945	165.215
8+00	164.315	164.410	164.409
9+00	163.615	163.708	163.650
10+00	163.148	163.190	163.129
11+00	162.589	162.599	162.489
12+00	161.904	161.899	161.659
13+00	161.378	161.369	161.250
14+00	160.481	160.727	160.581
15+00	160.304	160.255	160.156
16+00	159.952	159.889	159.787
17+00	159.617	159.667	159.477
18+00	159.592	159.682	159.591
19+00	159.516	159.574	159.446

DTM DESIGN STAGE

This stage represents a main part of the experimental work of this research. A digital model for the study area was established depending on computer programs developed to serve this purpose. The model construction is mainly dependent on the topographic map of Khaneqeen city of a **(1/100,000)** scale, drawn from aerial photographs of **(1/30,000)** scale taken for the study area in the year 1991.

Table 3.The coordinates (E,N,H) of selecting points of the road.

ta.	E	N	Dis.	H
1	518210.021	3784198.842	0.000 m	174.603
2	517941.651	3783782.906	500 m	166.120
3	517929.885	3783283.044	500 m	163.190
4	518126.861	3782826.744	500 m	160.190
5	518103.82	3782326.274	500 m	159.236
6	518353.455	3781837.95	500 m	154.099
7	518370.611	3781333.242	500 m	150.146
8	518572.643	3780882.444	500 m	138.581
9	518748.786	3780412.362	500 m	138.581
10	519008.862	3779987.662	500 m	151.584
11	519256.501	3779556.751	500 m	160.562
12	519434.649	3779089.564	500 m	164.342
13	519616.403	3778623.769	500 m	169.269
14	519645.382	3778126.613	500 m	160.998
15	520005.038	3777774.965	500 m	159.786
16	520222.111	3777325.654	500 m	166.261
17	520496.264	3776901.549	500 m	167.000
18	520801.467	3776492.952	500 m	176.756
19	521100.046	3776098.141	500 m	184.361
20	521339.329	3775663.676	500 m	182.256
21	521594.359	3775239.43	500 m	194.907
22	521796.454	3774787.564	500 m	191.369
23	522148.688	3774438.355	500 m	189.200
24	522539.682	3774134.795	500 m	173.981
25	522929.726	3773830.015	500 m	165.410
26	523285.499	3773485.849	500 m	155.981
27	523516.241	3773045.659	500 m	153.464
28	523731.181	3772598.65	500 m	161.350
29	523945.89	3772150.421	500 m	166.612
30	524132.872	3771689.936	500 m	156.158
31	524309.756	3771219.096	500 m	152.178
32	524316.742	3770709.406	500 m	154.155
33	524328.426	3770219.545	500 m	162.329

The design process of this model was illustrated and explained in serial steps in order to help the users of this model to understand the design operation quickly. Moreover, this was done to save time and effort spent during design process.

DTM Construction Steps

1- A separate contour lines' layer was made from the study area totpographic map, by projecting it on a trace paper used for this purpose, without indicating the value of each line. Understanding this step with more details can be achieved from the illustration contour line layer given in Figure 3 of the study area known as the contour map.

2- The contour map was inputed to the computer memory. This means to convert it to a digital form by using a scanner instrument with a resolution accuracy of about 400dpi and save it in a special work folder.

3- The contour map was converted from a grid map (raster map) to a vector map. This operation was fullfilled by using **(GTX. OSR ver.4.0)** software, which shows the contour lines in the first case as separate picture elements (pixles) having a gray-scale value and identified by (sample, line) coordinate format.In the second case, the contour line is identified by starting point **(x_1,y_1)** and ending point **(x_n,y_n)** coordinates. Between these two points there are many points known as (nodes), representing the changing in contour line direction.

4- Errors may result, when the contour lines are drawn. These errors, which enter into the drawing process, are dependent on the region (study area) nature. When the region includes many high slopes (i.e., very high contour line density), the probability of obtaining errors is increased, the probable error is that error resulting from the drawing of the dense contour lines. In addition, the processing includes also the errors in the map obtained as a result of the vectorization. These errors result from the cutting in the lines or the removing of the extra lines. Then, a reconstruction of contour lines is made in order to be ready for editing and identifying as contour lines having certain height values.

Figure (3): The contour map of the study area (Khaneqeen) as a separate layer.

Figure (4): Part of the study area with high slopes.

The above processing was done by using one of the **GIS** software **(Auto cad map, ver. 5.0).** This process is called clean up. Figure 4 illustrates a part of the study area including high slopes represented by dense contour lines.

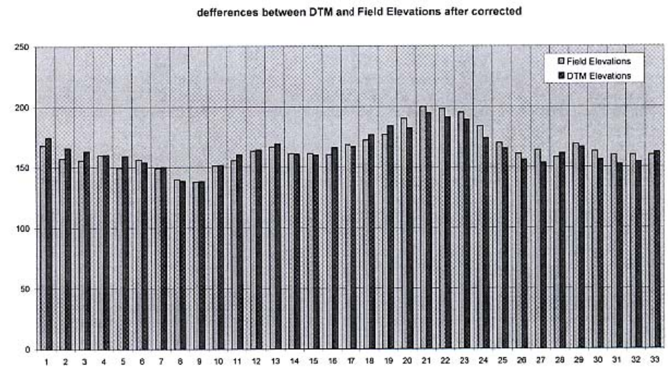

Figure (5): Difference between DTM and field elevation.

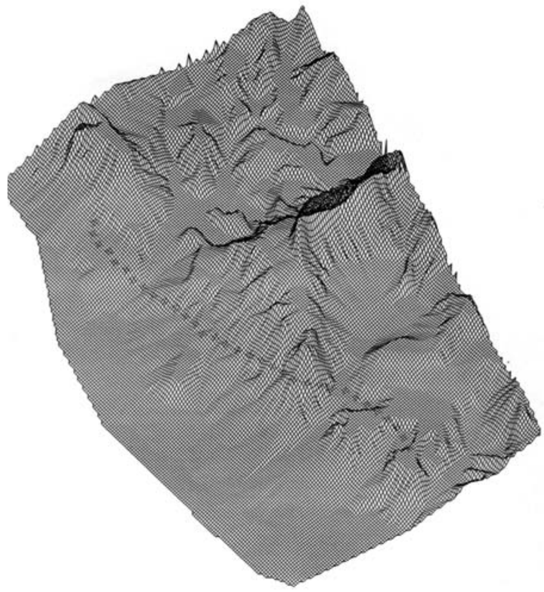

Figure (6): Digital terrain model for the study area.

Projection of the Surveyed Road

After DTM construction steps for the study region, each point in this model has three dimension coordinates **(x, y, z)**; so, one can project the field-surveyed road in the first stages of the work on this model because each point that is fixed in the field had three coordinates **(E, N, H)** and these coordinates are shown in Table (3).

The projection operation of these points is done directly after DTM design. This means that the work is still in the autocad program environment. Then, these points are projected on a separate layer by directly inputing the coordinates of each point.

After that, each work layer (original map layer, DTM layer and points' layer) shall be matched one with the other, and one layer as a result is obtained including DTM model with the surveyed road projected on it, as shown in Figure 6.

The differences between DTM and field elevation after a correction process indicated the model accuracy analysis as shown in Figure (5).

DATA ANALYSIS AND RESULTS

The reasons why the difference between the corresponding points (elevation) exceeds the acceptable range of the contour interval can be attributed to the following:

1- The scale of the drawing. The larger the scale used is, the greater is the accuracy obtained in line drawing, and hence the greater is the accuracy in the digital model (DTM). This can be obtained for scales larger than 1/100,000, e.g., (1/50,000, 1/25,000).

2- An error has occurred in the drawing of the contour line from aerial photographs, exactly in the "gap" area between the two curves. This is true, because if the error in the drawing were continuous to the end, the gap between the two curves would take place from the beginning and increase to the end, and not as in this case in which the gap is limited between the points (10 and 15).

In order to reduce the error; i.e., the difference between the DTM values and the field-measured ones for the aforementioned middle points, a simple correction procedure is made to correct the DTM values to lie within the acceptable contour interval. The correction process depended on the contour line holding the value 160, because this line caused the error that produced the gap between the two curves; so, the points' elevations were corrected according to that value.

Table 4. DTM Elv. and error values for points 10-15.

Point no.	DTM Elv. before correction	Error Value
10	139.90151	-20.09849
11	144.23715	-15.76285
12	152.12572	-7.87428
13	155.58312	-4.41688
14	150.00000	-10.00000
15	150.00000	-10.00000

$\Sigma = -68.1525$

Mean of Error = -68.1525 / 6 = -11.359

The correction factor for each point = 11.359

So, the new elevation (corrected) for these points would be as in Table (5).

Table 5. DTM elevations after correction.

Point no.	DTM Elv. before correction	DTM Elv. after correction (+11.359)
10	139.90151	151.26026
11	144.23715	155.5959
12	152.12572	163.48447
13	155.58312	166.94187
14	150.00000	161.35875
15	150.00000	161.35875

After the correction of DTM elevation values, the differences from the corresponding field-measured ones would be as given in Table (6).

Table 6. New difference values between DTM and field elevation.

Point no.	DTM Elv. after correction	Field Elv.	Δh = (DTM-field) Elv.
10	151.26026	151.584	-0.324
11	155.5959	160.562	-4.966
12	163.48447	164.342	-0.858
13	166.94187	169.269	-2.327
14	161.35875	160.998	0.361
15	161.35875	169.786	1.573

CONCLUSIONS

1- The Ground Control Points **(GCPs)** required in field surveying of engineering projects shall be identified easily through using enhanced satellite images of high resolution.

2- An investigation of the two curves in Figure (5) shows that most of the points in field measurements curve coincide with the corresponding points in DTM measurements curve. The percentage of coincidence was about 82% which makes the DTM quite recommended to be used in future works for highway design as a replacement to the conventional methods of preliminary design and surveying.

3- From the results of this work, the elevation differences between the field measured and DTM measured elevation values for the points (10, 11, 12, 13, 14, 15) had exceeded the contour interval limits (10 m) for the studied map used for the design. An approximate correction method was made for the DTM measured elevations of points, for it may be subjected to error more than the field measured ones. An average value method was used in the correction.

4- The results of the DTM by scanned contour line method are obtained in a quite short time in comparison with the conventional method (spot height method). In addition, the results are of high accuracy in representing the topography. It is, accordingly, highly recommended to be adopted and applied.

APPENDIX A1

Figure 1. Raw image of the study area (Khaneqeen)

APPENDIX A2

Figure 2. An enhanced image of the study area

APPENDIX A3

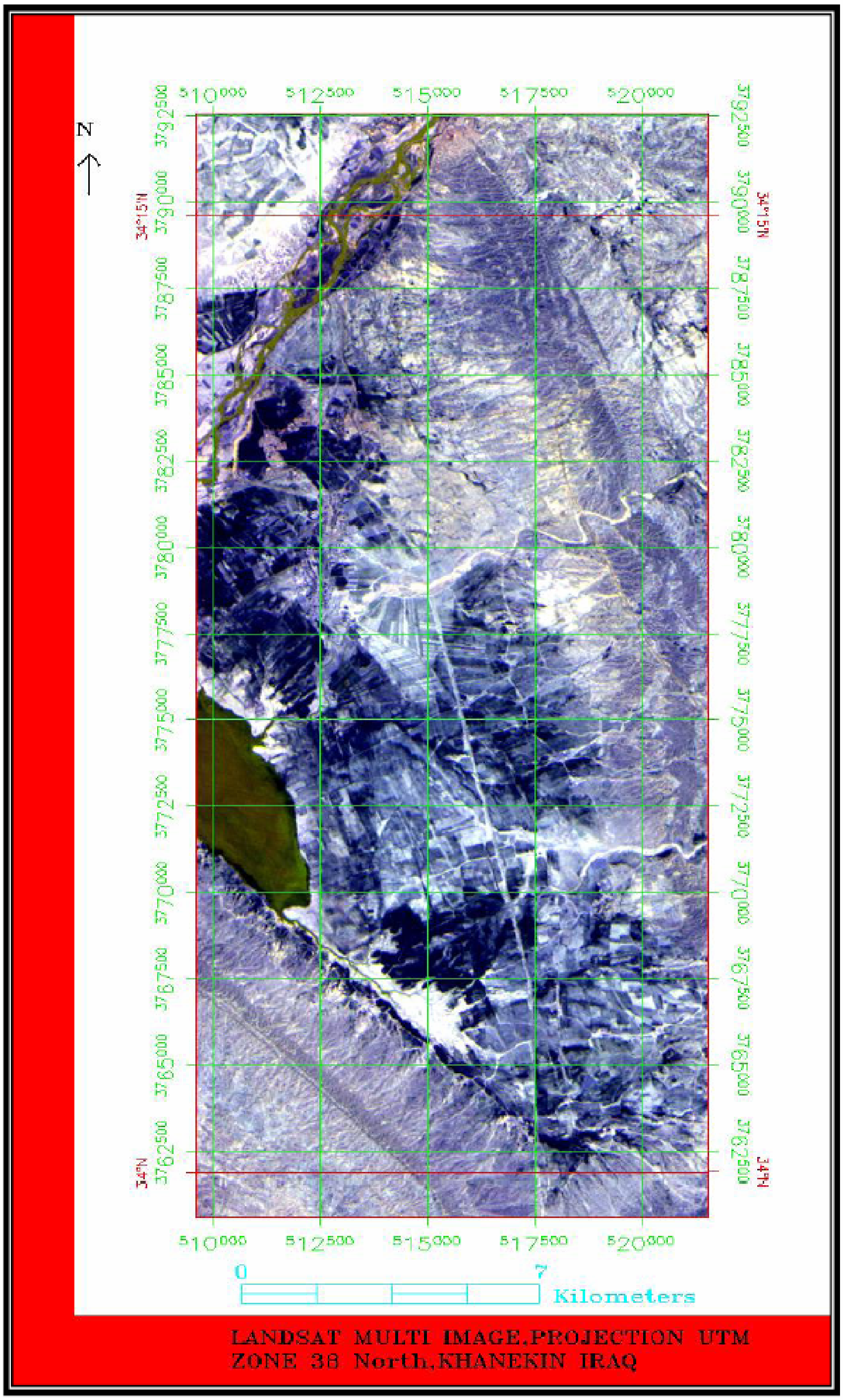

Figure 3. Enhancement image of study area with projected grid

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