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Positional Accuracy of the Google Earth Imagery In The Gaza Strip

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***Abstract*— Google Earth provides an open source, easy to access and cost free image data that support map interest community. The aim of this research is to estimate the Google Earth horizontal positional accuracy in Khan Younis City as a study area to evaluate this free source of data. Since GPS provides an accurate measurement of coordinates on the same ellipsoid as Google Earth, it is used to check the spatial horizontal accuracy of Google Earth. This is carried out by comparing Google Earth measured coordinates with their counterparts from Global Positional System (GPS) measured coordinates. A sample of 40 check points distributed in the City is chosen for this purpose. Linear error of horizontal positional accuracy is computed and is found to be 39.24 m. This value is very critical and disappointed to find such difference in accuracy between Gaza and the other world. So this study recommends that although Google Earth represents a powerful and attractive source of positional data, but it is critical to use it for studies otherwise for limited issues in the Gaza Strip. In the Gaza Strip, Google Earth should not be used in measurement of coordinates and when it is needed to use Google Earth in spatial data, it is recommended to use it in investigation and preliminary studies taking into account the scale of error computed in this research.**

Keywords—Google Earth; positional accuracy; Gaza Strip; imagery; GPS

I. Introduction

Google Earth is a virtual globe, map and geographical information program that was originally called Earth Viewer 3D, and was created by Keyhole, Inc., a Central Intelligence Agency (CIA) funded company acquired by Google in 2004. It maps the Earth by the superimposition of images obtained from satellite imagery, aerial photography and GIS 3D globe. Google Earth uses digital elevation model (DEM) data collected by NASA's Shuttle Radar Topography Mission (SRTM). The internal coordinate system of Google Earth is geographic coordinates (latitude/longitude) on the World Geodetic System of 1984 (WGS84) datum i.e., the same datum that is used by GPS [1]. Google Earth shows the earth as it looks from an elevated platform such as an airplane or orbiting satellite. The projection used to achieve this effect is called the general perspective. This is similar to the orthographic projection. Most of the high resolution imagery in Google Earth maps is the Digital Globe Quick-bird which is roughly 65 cm pan-sharpened (65 cm panchromatic and 2.62 m multispectral at nadir). Google is actively replacing this base imagery with 2.5 m SPOT Image imagery and several higher resolution datasets [1].

II. Problem in the Gaza Strip

In the Gaza Strip, Google Earth is widely used as a source of spatial data, especially after the recent war of 2014 in order to document and evaluate the damage of houses and other assets. Unfortunately, low resolution images are available for the occupied Palestinian territories on Google Earth. The clearest images of the Gaza Strip are blurred and unclear. On the other hand, high resolution images are available on Google Earth for other areas of the World that allow to zoom in and see more better details. Figure 1 shows images published on Google Earth in 2017 for Khan Younis City in the Gaza Strip and New York in USA. The images are at the same scale.

Fig. 1. *Khan Younis and New York Cities from the same elevation in Google Earth.*

In short, the images of Palestine are censored by the U.S. government. The U.S. Defense Authorization Act of 1997 contains a clause entitled "Prohibition on collection and release of detailed satellite imagery relating to Israel". A Google Earth spokesperson explained that "the images in Google Earth are sourced from a wide range of both commercial and public sources. We source our satellite imagery from US-based companies who are subject to US law, including the Kyl-Bingaman Amendment to the National Defense Authorization Act of 1997, which limits the resolution of imagery of Israel that may be commercially distributed"[2]. In technical terms, commercially available images of the Gaza Strip are limited to a resolution 2.5 meters per pixel, compared with a maximum resolution of around 0.5 m per pixel from current commercial satellites (that is a 25 times less detail than what would otherwise be visible). Thus, there is a great need to know exactly the positional accuracy of data image with reference to real data measurements prior to use it. This study aims to stand on to what extent Google Earth can be used in the Gaza Strip as a spatial data source.

III. Coordinate System of Palestine

Many countries have upgraded their old coordinate systems that refer to the 19th century or the beginning of the 20th century. They have switched to newer and more accurate spheroids like WGS84, which is being the base for determining location in Global Positioning System GPS, or use another projection as Universal Transverse Mercator UTM. Typically, the data imported into the Google Earth application is created with a specific geographic coordinate system, such as a Universal Transverse Mercator (UTM) projection and a NAD27 datum (North American Datum of 1927). Each geographic coordinate system may assign slightly different coordinates to the same location on the earth. When it is imported into Google Earth, data is interpreted according to the Google Earth coordinate system [3]. Particularly in Palestine, the used coordinate system was established by the British Military Survey in 1923. This system is based on "Palestine 1923" datum that corresponds to "Clarke 1880" spheroid and a transverse cylindrical projection called Cassini-Soldner [4]. The central meridian, the line of longitude along which there is no local distortion, was chosen as that passing through a marker on the hill of Mar Elias Monastery south of Jerusalem. The false origin (zero point) of the grid was placed 100 km to the south and west of the El-Muntar hill that overlooks Gaza City [5]. The unit length for the Palestine grid was the kilometer. Table 1 shows the parameters needed to define the Palestine Grid.

TABLE 1. Palestine Grid parameters

Palestine Grid		
Transformation	Shift dx =	198.1470 m
	Shift dy =	111.9940 m
	Shift dz =	-210.0640 m
	Rotation X =	-7.85790 min
	Rotation Y =	-7.51130 min
	Rotation Z =	-4.75720 min
	Scale μ =	-2.3308 ppm
Ellipsoid	Clarke 1880 Palestine – mod.	a = 6378300.7890 m
		1/f = 293.46600000
Projection	Cassini Soldner	F.E. = 170251.5550 m
		F.N. = 126867.9090 m
		Φ_0 = 31°44'02.74900"
		λ_0 = 35°12'43.49000"

IV. The Study Area

Khan Younis Governorate is a part of the Gaza Strip. It is located in the south of the Gaza Strip, (Fig. 2), bounded by Deir al Balah City to the north and Rafah City in the south. It covers an area of about 116 km^2 (about 31% of the Gaza Strip total area). According to the Palestinian Central Bureau of Statistics, the population recorded about 369,048 inhabitants in year 2013 (about 19.1% of the Gaza Strip total population) [6]. The built-up area occupies an area of about 18 km^2, while the agricultural lands cover an area of about 63 km^2. The area is generally flat with topographic elevation ranging from mean sea level (MSL) in the west to about 100 m above MSL in the east.

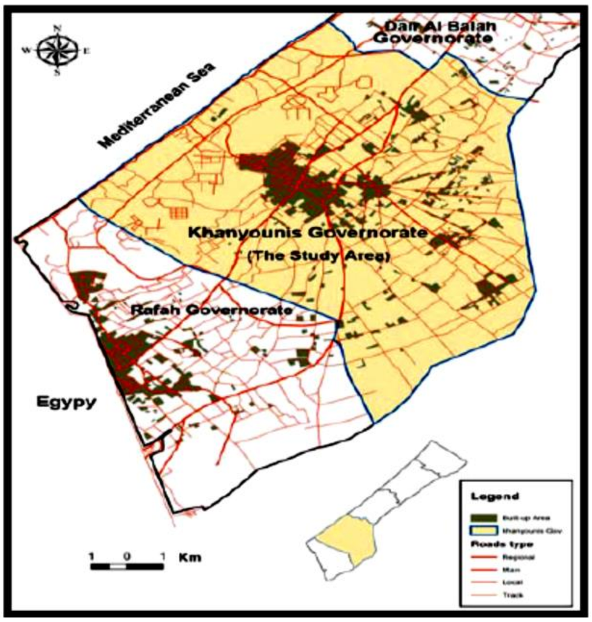

Fig. 2. *Khan Younis Governorate.*

V. Positional Accuracy

A. Field Survey Using GPS

To achieve the research aim, two Leica GS15 GNSS receivers are used to compute field coordinates. The rover receiver set up is normally over the points that we need to determine their coordinates while the base receiver is fixed at a control point station of the Palestine Grid Network. A traditional static survey is selected for this purpose. Both receivers measurements and readings are transmitted to the computer and processed using Leica Geo Office post processing software to obtain the rover adjusted coordinates. The expected positioning accuracy ranges from 2 to 5 mm. Using the traditional static GPS survey, 40 field checkpoints are selected in Khan Younis area. The base receiver remains stationary over the known point (Municipality Station). Fig. 3 shows the layout and distribution of the checkpoints. The computed rover coordinates for the entire survey is stored and downloaded using GIS software for further analysis. The result for the field survey is shown in Table 2. Data for checkpoints number 15 and 36 contain blunders and thus are excluded.

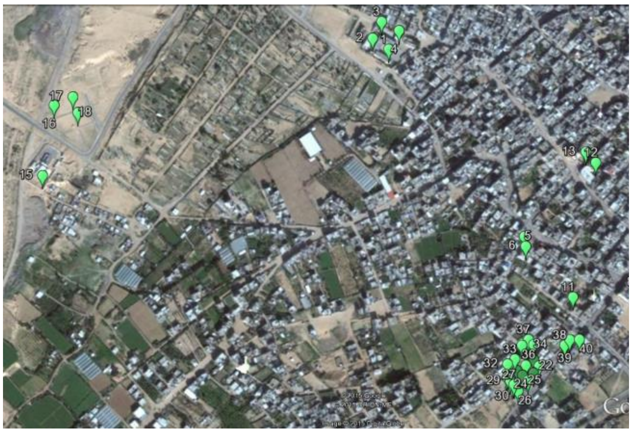

Fig. 3. *Distribution of checkpoints.*

TABLE 2. GPS FIELD SURVEY RESULTS

No	Easting (x) (m)	Northing (y) (m)
1	82733.0877	83783.7265
2	82692.032	83812.2597
3	82714.0017	83848.2552
4	82758.2082	83824.6811
5	83044.2834	83338.9094
6	83047.4651	83315.7004
7	83337.6456	83186.0236
8	83309.4345	83206.0191
9	83342.6112	83245.9334
10	83359.241	83224.8188
11	83160.2482	83193.7469
12	83218.076	83510.3644
13	83196.6259	83534.1047
14	82193.1364	84010.2198
16	81936.5596	83659.9178
17	81982.8151	83676.4955
18	81996.4599	83639.9758
19	82405.0699	81917.2138
20	82940.3817	82841.7782
21	83066.7064	83046.2507
22	83066.7064	83034.156
23	83064.9384	83016.7385
24	83048.0766	83034.023
25	83051.3585	83000.7621
26	83030.2934	82977.4166
27	83021.6155	82987.0057
28	83042.5772	83010.4589
29	83014.5651	82995.5151
30	83006.6867	83005.9991
31	83030.9818	83022.7777
32	83005.2184	83037.1658
33	83023.0791	83048.8578
34	83060.0135	83085.2234
35	83043.4738	83071.2427
37	83049.0935	83095.4877
38	83138.9779	83080.7585
39	83152.0407	83094.0062
40	83174.2697	83095.9527

B. Google Earth Survey

Table 3 shows the geographic coordinates of the 40 checkpoints study sample as they are extracted from Google Earth in decimal degree. To gain the highest accuracy, zooming in as largest as possible is used. Latitudes and Longitudes are referred to WGS 84 datum. Measurements of checkpoints 15 and 36 are also ignored.

TABLE 3. GOOGLE EARTH SURVEY RESULTS

No	Latitude (ϕ)	Longitude (λ)
1	31.34271944	34.29350278
2	31.34295278	34.29310278
3	31.34330278	34.29332500
4	31.34311111	34.29375833
5	31.33872222	34.29684167
6	31.33851667	34.29687778
7	31.33736111	34.29995833
8	31.33754167	34.29963056
9	31.33786111	34.29997500
10	31.33772500	34.30015833
11	31.33743889	34.29805833
12	31.34029444	34.29865000
13	31.34051944	34.29839722
14	31.34471389	34.28781944
16	31.34153333	34.28516667
17	31.34170833	34.28563333
18	31.34137222	34.28575278
19	31.32587222	34.29022222
20	31.33423611	34.29580833
21	31.33609722	34.29709722
22	31.33596667	34.29722222
23	31.33581667	34.29708611
24	31.33598333	34.29689444
25	31.33565833	34.29694444
26	31.33543889	34.29670000
27	31.33557500	34.29659722
28	31.33576944	34.29681389
29	31.33565000	34.29650556
30	31.33573056	34.29643056
31	31.33586944	34.29667778

No	Latitude (ф)	Longitude (λ)
32	31.33600833	34.29644167
33	31.33611667	34.29662222
34	31.33642500	34.29708333
35	31.33631389	34.29679167
37	31.33653611	34.29695833
38	31.33641389	34.29785833
39	31.33652778	34.29798333
40	31.33653333	34.29822500

These coordinates in Table 3 are transformed to the Palestine Grid coordinate system for the purpose of unifying the readings both in GPS field and Google Earth surveys as shown in Table 4.

TABLE 4. GOOGLE EARTH RESULTS IN LOCAL GRID

No	Easting (x) (m)	Northing (y) (m)
1	82769.16809	83794.04945
2	82731.31852	83820.2373
3	82752.78604	83858.87161
4	82793.84569	83837.27776
5	83083.24157	83348.19902
6	83086.49021	83325.37795
7	83378.59433	83194.83387
8	83347.56595	83215.11076
9	83380.63568	83250.26263
10	83397.95853	83235.02686
11	83197.85251	83204.94477
12	83256.76218	83521.1158
13	83232.91267	83546.26252
14	82230.18752	84019.68938
16	81974.8129	83669.12165
17	82019.38294	83688.15567
18	82030.43841	83650.79154
19	82441.48923	81928.55523
20	82980.80278	82851.57375
21	83105.16332	83056.92914
22	83116.93982	83042.35467
23	83103.84966	83025.82885
24	83085.76175	83044.45974
25	83090.22315	83008.38336
26	83066.75974	82984.2423
27	83057.10313	82999.41541
28	83077.90017	83020.80615
29	83048.44809	83007.80359
30	83041.38424	83016.79472
31	83065.03837	83032.00127
32	83042.69555	83047.587

No	Easting (x) (m)	Northing (y) (m)
33	83059.97729	83059.45774
34	83104.14097	83093.2852
35	83076.28282	83081.19353
37	83092.34678	83105.70362
38	83177.88414	83091.44576
39	83189.88376	83103.97625
40	83212.88715	83104.40299
21	83105.16332	83056.92914
22	83116.93982	83042.35467
23	83103.84966	83025.82885
24	83085.76175	83044.45974
25	83090.22315	83008.38336
26	83066.75974	82984.2423
27	83057.10313	82999.41541
28	83077.90017	83020.80615
29	83048.44809	83007.80359
30	83041.38424	83016.79472
31	83065.03837	83032.00127
32	83042.69555	83047.587
33	83059.97729	83059.45774
34	83104.14097	83093.2852
35	83076.28282	83081.19353
37	83092.34678	83105.70362
38	83177.88414	83091.44576
39	83189.88376	83103.97625
40	83212.88715	83104.40299

C. Analysis and Discussion

Differences between actual observed GPS coordinates of the sample points and the Google Earth measured coordinates are computed and tabulated in Table 5.

TABLE 5. ERROR BETWEEN GPS AND GOOGLE EARTH DATA

No	ε_x (m)	ε_y (m)
1	36.080392	10.322951
2	39.286519	7.977603
3	38.784335	10.616414
4	35.637485	12.596657
5	38.958167	9.289616
6	39.025106	9.677548
7	40.948733	8.81027
8	38.131445	9.091656
9	38.024478	4.329228
10	38.717526	10.208062
11	37.604307	11.19787
12	38.686182	10.751402

No	ε_x (m)	ε_y (m)
13	36.28677	12.157819
14	37.05112	9.469582
16	38.253297	9.203848
17	36.56784	11.660169
18	33.978505	10.81574
19	36.419328	11.341428
20	40.42108	9.795552
21	38.4569	10.6784
22	50.2334	8.19867
23	38.9113	9.09034
24	37.6851	10.4367
25	38.8646	7.62126
26	36.4663	6.8257
27	35.4876	12.4097
28	35.323	10.3472
29	33.883	12.2885
30	34.6975	10.7956
31	34.0566	9.22357
32	37.4771	10.4212
33	36.8982	10.5999
34	44.1275	8.0618
35	32.809	9.95083
37	43.2533	10.2159
38	38.9062	10.6873
39	37.8431	9.97005
40	38.6174	8.45029
21	38.4569	10.6784
22	50.2334	8.19867
23	38.9113	9.09034
24	37.6851	10.4367
25	38.8646	7.62126
26	36.4663	6.8257
27	35.4876	12.4097
28	35.323	10.3472
29	33.883	12.2885
30	34.6975	10.7956
31	34.0566	9.22357
32	37.4771	10.4212
33	36.8982	10.5999
34	44.1275	8.0618
35	32.809	9.95083
37	43.2533	10.2159
38	38.9062	10.6873
39	37.8431	9.97005
40	38.6174	8.45029

No	ε_x (m)	ε_y (m)
Mean	$\varepsilon_X = 37.970$	$\varepsilon_Y = 9.884$
Average linear Error (m)		$\varepsilon = 39.235$

The shift error in Easting direction ranges between a minimum value of 32.809 m up to a maximum value of 50.233 m. The average shift error in Easting is + 37.970 m. On the other hand, the shift error in Northing direction ranges between a minimum value of 4.329 m up to a maximum value of 12.597 m. The average shift error in Northing is + 9.884 m. Thus, the linear shift error equals 39.235 m to the North-East direction. This means if it is required to use Google Earth as a source of spatial data and to enhance its positional horizontal accuracy, correction values of – 37.970 m and – 9.884 m should be added to the values of Easting and Northing coordinates respectively.

VI. Conclusion and Recommendations

Google Earth is widely used as a source of spatial data in the Gaza Strip. Unfortunately, low resolution images are available for the occupied Palestinian territories on Google Earth. The clearest images of the Gaza Strip are blurred and unclear. Forty field checkpoints in Khan Younis Governorate are selected to estimate the positional accuracy of Google Earth data image with reference to real data measurements prior to use it. The study shows that the horizontal accuracy of positions has a value of 39.235 m to the North-East direction. As a result of this study, restricted limitation for using Google Earth in positioning issues should be widely considered. When it is needed to use Google Earth in accurate spatial data purposes, it should be for investigation and preliminary studies taking into account the scale of error computed in this study.

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