Positional Accuracy Testing of Google Earth

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Abstract- Google Earth provides an open source, easy to access and cost free image data that support map interest community. Therefore, depending of this community on Google Earth, grows up day by day. More than simply providing locational information, Google Earth allows users to add their own content such as photos or descriptions of areas or landmarks. They can also extrapolate information from the satellite imagery obtained by digitizing areas of interest and exporting them for use elsewhere. As such, the application has found a strong following not only in explorers and navigators but also in classrooms all over the world. However, this popularity of Google Earth is not an indication of its accuracy. The aim of this research is to estimate the Google Earth horizontal and vertical accuracy in Khartoum State so as to evaluate this free source of data. This was carried out by comparing Google Earth measured coordinates of points with geodetic Global Positional System (GPS) receiver coordinates over sample of 16 check points located in Khartoum State. Since GPS provide accurate measurement of coordinates on the same ellipsoid as Google Earth, it was used to check the accuracy of Google Earth. Root Mean Square Error (RMSE) was computed for horizontal coordinates and was found to be 1.59m. For height measurement RMSE was computed to be 1.7m. For the research purposes and to pursue the changes occurred while Google Earth images updated, it was noted that the positional accuracy was changed and improved, but the elevation is still as it were before update.

Keywords- Google Earth, GPS, Projection, Datum and Positional Accuracy

I. INTRODUCTION

S ince it was released in June 2005, Google Earth has enjoyed ever increasing popularity as the go-to application for map lovers, navigators and armchair explorers. Free for download and installation on every computer system – PC, Mac and Linux. Via satellite imagery, maps, terrain, 3D buildings and other locational data. Google aims to provide viewers with "a more realistic view of the world".

Beside Google Earth, map data and positional measurement can be obtained using different methods such as conventional or modern land survey methods, Global positional System (GPS) and remote sensing satellite imagery. Each of theses methods is of a known positional accuracy.

The positional accuracy generally includes:

- Horizontal accuracy that evaluate the measured (X,Y) planimetric coordinates of the points relative to the true coordinates, and
- Vertical accuracy that evaluate the measured height (h) of the points relative to the true heights.

II. 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 used by GPS.

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 Quickbird which is roughly 65cm pansharpened (65 cm panchromatic at nadir 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.

Some population centers are also covered by aircraft imagery (orthophotography) with several pixels per meter.

Google Earth file format is Keyhole Markup Language (KML) which is a file format for modeling and storing geographic features such as points, lines, images, polygons, and models for display in Google Earth, Google maps or other applications. It can use KML to share places and information with other users of these applications. For its reference system, KML uses 3D geographic coordinates; longitude, latitude and altitude, in that order, the longitude, latitude components are as defined by the World Geodetic System of 1984 (WGS84). The vertical component (altitude) is measured from the WGS84 EGM96 Geoid vertical datum.

III. MAP PROJECTION

A map projection is a way to represent the curved surface of the Earth on the flat surface of a map. A good globe can provide the most accurate representation of the earth. However, a globe isn't practical for many of the functions for which it requires maps. Map projections allow users to represent some or the earth's entire surface, at a wide variety of scales, on a flat, easily transportable surface, such as a sheet of paper. Map projections also apply to digital map data, which can be presented on a computer screen.

There is three main type of surfaces that globe can be projected on. These include:

- i). Azimuthal (projection into a plane)
- ii). Conical and
- iii). Cylindrical

Universal Transverse Mercator (UTM) is a 'pseudo cylindrical' conformal projection (it preserves shape). The UTM system divides the earth into 60 zones each 6 degrees of longitude wide. These zones define the reference point for UTM grid coordinates within the zone. UTM zones extend from latitude of 80° S to 84° N. In the Polar Regions the Universal Polar Stereographic (UPS) grid system is used.

UTM zones are numbered 1 through 60, starting at the International Date Line, longitude 180° , and proceeding east. Zone 1 extends from 180° W to 174° W and is centered on 177° W.

Each UTM zone is divided into horizontal bands spanning 8 degrees of latitude. These bands are lettered, south to north, beginning at 80° S with the letter C and ending with the letter X at 84° N. The letters I and O are skipped to avoid confusion with the numbers one and zero. The bands lettered X spans 12° of latitude Where, Sudan falls in zone 36N.

Scale factor is the ratio of any two corresponding lengths measured between two points (i.e. projected and actual length). In UTM the default scale factor value is (0.9996) m.

Practically, for each region of the earth there is a suitable map projection (i.e., in the poles the adopted projection is the UPS system), in the same manner, for each country there is a suitable datum, which is a reference for position on the surface of the earth.

IV. GEODETIC DATUMS

In surveying, a datum is a reference system for computing or correlating the results of surveys. There are two principal types of datum; vertical and horizontal:

- A vertical datum is a level surface to which heights are referred.
- The horizontal datum is used as a reference for positions.

The World Geodetic System 1984 (WGS84) is the geodetic reference system used by GPS. WGS84 was developed for the United States Defense Mapping Agency (DMA), now called NIMA (National Imagery and Mapping and Agency).

The International Terrestrial Reference Frame (ITRF) which is an international coordinate framework having the earth's center of mass as its origin. ITRF is computed annually from a global network of accurate coordinates and is now sufficiently refined that the change between successive ITRF epochs is in the order of a couple of centimeters only. These coordinates are derived from geodetic observations such as GPS, Very Long Baseline Interferometry (VLBI), and Satellite Laser Ranging (SLR).

Although the name WGS84 has remained the same, it has been enhanced on several occasions to a point where it is now very closely aligned to ITRF. The origin of the WGS84 framework is also the earth's centre of mass.

The reference ellipsoid used with WGS84 is essentially the same as the Geodetic Reference System 1980 (GRS80) and ellipsoid used with ITRF. WGS84 reference ellipsoid parameters are:

- Equatorial axis = 6378173.00 m.
- Polar axis = 6356 752.3142 m.
- Inverse flattening (1/f) = 298.257 223 563 m.

V. MEASUREMENT AND RESULTS

In order to evaluate the positional accuracy of Google Earth, number of sixteen points was selected in Khartoum town. These points were then observed using Trimble 1800 surveying GPS receiver applying Real Time Kinematic (RTK) technique. In which the base station was located in Khartoum air port at fixed control point and the rover was used to observe the required points. Figure 1 shows part of Google Earth image demonstrating the study area and points distribution.



Figure 1: Distribution of the selected points over the study area



Figure 2: A sample of observed points

Figure 2 shows an enlarged image demonstrating sample of observed points.

Results of GPS observations were tabulated as shown in Table 1 hereunder.

Table 1	1: GPS	observed	coordinates
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	Observed coordinates			
point	X (m)	Y(m)	H(m)	
1	447285.46	1720556.50	381.98	
2	447640.33	1723463.06	381.43	
3	447832.56	1725289.75	380.97	
4	449810.47	1719955.92	383.40	
5	450022.15	1725641.94	381.29	
6	450253.05	1724235.07	383.33	
7	450891.91	1722483.98	383.64	
8	452122.27	1720294.16	385.23	
9	452155.23	1725766.07	382.96	
10	452618.83	1724872.69	383.79	
11	452907.50	1722494.06	383.94	
12	454501.44	1722715.48	384.19	
13	454616.56	1726038.41	382.56	
14	454803.59	1720767.42	385.14	
15	455012.05	1724513.72	384.58	
16	455026.51	1724515.18	384.20	

In September 2012 Google Earth was used to measure the location of the sixteen study points. Results of Google Earth measurement was found to be as listed in Table 2:

Table 2: Google Earth measured coordinates in September 2012

Point	Measured coordinates			
Point	X(m)	Y(m)	H(m)	
1	447286	1720559	380	
2	447640	1723466	381	
3	447833	1725294	384	
4	449813	1719958	384	
5	450025	1725645	384	
6	450256	1724237	384	
7	450895	1722487	383	
8	452125	1720296	383	
9	452156	1725769	382	
10	452621	1724875	380	
11	452910	1722496	382	
12	454504	1722718	385	
13	454620	1726041	382	
14	454807	1720770	386	
15	455015	1724516	384	
16	455029	1724518	384	

In October 2012, a new Google Earth set of positional measurement was carried out. Result of this measurement is listed in Table 3:

Table 3: Google Earth measured coordinates in October 2012

Point	Measured coordinates				
Point	X(m)	Y(m)	H(m)		
1	447283.39	1720556.17	380		
2	447639.00	1723462.30	381		
3	447831.44	1725290.90	384		
4	449809.02	1719955.97	384		
5	450021.05	1725642.97	384		
6	450254.60	1724237.00	384		
7	450890.51	1722484.21	383		
8	452120.81	1720294.14	383		
9	452151.87	1725765.58	382		
10	452616.75	1724872.72	380		
11	452906.07	1722494.09	382		
12	454500.28	1722715.58	385		
13	454614.85	1726038.29	382		
14	454802.30	1720767.46	386		
15	455010.48	1724513.75	384		
16	455025.16	1724515.12	384		

Differences between actual observed GPS coordinates of points and the two sets of Google Earth measured coordinates were computed as listed below in Table 4:

Table 4: Differences between actual and Google Earth observed coordinates in September and October 2012

	Differences in coordinates			
Point	September		October	
	$\Delta X(m)$	$\Delta \mathbf{Y}(\mathbf{m})$	$\Delta X(m)$	$\Delta \mathbf{Y}(\mathbf{m})$
1	0.54	2.5	-2.07	-0.33
2	-0.33	2.94	-1.33	-0.76
3	0.44	4.25	-1.12	1.15
4	2.53	2.08	-1.45	0.05
5	2.85	3.06	-1.1	1.03
6	2.95	1.93	1.55	1.93
7	3.09	3.02	-1.4	0.23
8	2.73	1.84	-1.46	-0.02
9	0.77	2.93	-3.36	-0.49
10	2.17	2.31	-2.08	0.03
11	2.5	1.94	-1.43	0.03
12	2.56	2.52	-1.16	0.1
13	3.44	2.59	-1.71	-0.12
14	3.41	2.58	-1.29	0.04
15	2.95	2.28	-1.57	0.03
16	2.49	2.82	-1.35	-0.06
RMSE	2.47	2.66	1.68	0.67
RMSE _{XY}	3.63		1.80	

Computing the Root Mean square (RMSE) - as an accuracy indicator - for planimetric coordinates (X, Y) it was found to be 3.63m in September 2012, while it was computed to be 1.80m in October.

It can be noted that the accuracy of Google Earth was changed from September to October but, fortunately enhanced

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to provide better accuracy. This may be caused by updating Google Earth images with a new better resolution one. On the other hand, no change was noted in the heights derived from Google Earth on both measurement of September and October.

Google Earth measured heights were also tested by comparing actual heights observed by GPS and those measured in Google Earth after updating in October 2012. Differences in heights were computed to be as listed in Table 5:

point	GPS Heights (m)	Google Heights (m)	ΔH(m)
1	381.987	380	3.92
2	381.438	381	0.18
3	380.976	384	9.18
4	383.403	384	0.36
5	381.299	384	7.34
6	383.334	384	0.44
7	383.643	383	0.40
8	385.236	383	4.97
9	382.967	382	0.92
10	383.796	380	14.36
11	383.945	382	3.76
12	384.199	385	0.65
13	382.568	382	0.31
14	385.148	386	0.73
15	384.581	384	0.33
16	384.204	384	0.04
RMSE _H			1.73m

Table 5: Difference between actual and Google Earth measured heights

From results of Table 5, it can be note that Google Earth provides elevations with accuracy of approximately of 1.73m as a result of computing RMSE for height.

VI. CONCLUSION

Availability of data that make users in different disciplines use Google Earth in positional data extraction encourage specialists to carry out researches in order to test and evaluate positional Google Earth extracted data.

From the measurements carried out in year 2012 and results obtained above, it can be concluded with:

- Google Earth positional accuracy is not fixed but varies from time to another. This may be referred to the process of updating Google Earth by replacing the original images by a better resolution images.
- In spite of changing the positional accuracy positively to be better, but the negative change may be expected.
- Reliability of Google Earth extracted positional data can be supported by making some sort of field check.
- Horizontal accuracy of Google Earth in Khartoum area (Sudan) is about 1.80m. This accuracy can successfully be used to derive planmetric maps with medium and small scales.

- Moreover, height information can be extracted from Google Earth was estimated with 1.73m accuracy. This accuracy enables specialists to have topographic information and assist to produce contour maps with 1:50,000 scale and smaller.
- Google Earth represents a powerful and attractive source of positional data that can be used for investigation and preliminary studies with suitable accuracy and low cost.

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