Enhancement of Google Earth Positional Accuracy

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***Abstract* - Google Earth is one of many online mapping applications that offer users interactive mapping capabilities. It is often being used by academic users as a source for reference or base maps. It provides an open source, easy access and cost free image data that support map interest community. This contemporary high resolution archive of the Earth's landmass represents a significant, rapidly expanding and largely unexploited resource for scientific inquiry. Therefore, many individuals and researchers still use Google Earth as a reliable and accurate data source for mapping applications. This issue raises questions about the expected positional accuracy of Google Earth, which is the main interest of the current research. In this context, the positional accuracy assessment was not carried out directly on the Google Earth imagery, but on a selected scene for a certain study area that resulted in a corresponding non georeferenced image. Then, it is georeferenced with the aid of some control points in order to be compared with a base ground surveying map, on which the accuracy assessment will depend on the coordinates' discrepancies of some selected well-defined check points. The results show a significant improvement on the horizontal accuracy, related to all previous similar researches, that finally yields to sub-meters accuracy in the horizontal positions. However, this finding can be valid in the place of study, besides coordinates extracted from Google Earth imagery should be used with care caution.**

Keywords - Google Earth; Georeferencing; Positional Accuracy

I. INTRODUCTION

Due to the popularity of Google Earth as an application for map lovers, navigators and armchair explorers, users commonly assume that it is a credible and reliable source of information since it was released in June 2005 [1]. World level coverage of Earth is available by the superimposition of images obtained from satellite imagery, aerial photography, streets, points of interest and GIS 3D globe. This virtual globe is one of the most popular applications being used by both GIS and non GIS users. The Google Earth service has many tools that allow users to not only extract spatial data but also to add their own content to the imagery, such as photographs, landmarks and notes [2]. Now, the high-resolution imagery that Google Earth hosts allows human observers to readily discriminate between major natural land cover classes and to discern components of the human built environment, including; individual houses, industrial facilities, and roads [3].

Within this popularity of Google Earth, users tend to assume that it is an accurate source of information and also tend not to question its credibility. In addition, its derived coordinates usually being reported with a precision that does not match its accuracy, which misleads users to believe that it is an accurate source of information. Therefore, in order to understand and reduce the uncertainties associated with the use of Google Earth in different applications, accuracy assessments of its corresponding imagery are required. Consequently, a series of accuracy assessments of Google Earth imagery have been undertaken by different researchers [4]. Unfortunately, nearly all researchers do not state clearly a unique estimated accuracy according to various factors that govern the output, but they totally recommend that Google Earth coordinates should be handled with caution [5].

This research presents an assessment study of the horizontal positional accuracy of Google Earth within a certain area in Cairo. It differs from other previous investigations that the assessment will not be carried out upon directly derived Google Earth coordinates, but on a georeferenced scene that is captured from Google Earth imagery. Accordingly, the paper starts with a clear identification and explanation of the undertaken methodology. This will be followed by the description of the field experiment along with an illustration of both selected control and check points upon which the georeferencing and assessment will be discussed. Moreover, the obtained results will be manipulated, statistically analyzed and compared with other related researches. Finally, the main conclusions along with some appropriate recommendations are presented.

II. METHODOLOGY

As stated before, the horizontal positional accuracy of Google Earth will not be assessed upon the directly derived coordinates from the online image. Instead, a selected scene is captured as an image of the tested area, that will be compared with the corresponding base map produced by ground surveying techniques. This test region area is part of Ain Shams University campus along with surrounding streets and landscapes. This area was surveyed by Topcon 712 GTS total stations from two ground control stations. Their corresponding coordinates are precisely determined by a Trimble R3 precise GPS geodetic receiver.

The process involved Georeferencing of the image obtained by Google Earth for the Ain Shams University to six well defined and sharp reference ground control points, including the two previously-mentioned control points, in order to apply the required coordinate transformation. These reference points are selected from the AutoCAD map for Ain Shams University. Fig. 1 shows the selected test area along with the used six common points. The ERDAS IMAGINE 8.4 software is used for Georeferencing the image, were the Universal Transverse Mercator projection (UTM) projection was used with zone number 36. The geometric model used is the second order polynomial and the resampling method used is the Nearest Neighbor to obtain the rectified image, within a resolution of 0.25 x 0.25 meter.

Finally, Sixteen check points were selected in order to evaluate the horizontal positional accuracy of Google Earth. The assessment depends on the discrepancies in the 2D planimetric ground coordinates (E, N) of all selected check point, which is simply the difference between the computed coordinates from both used Google Earth images and the actual reference ground coordinates. In addition and for instance, the discrepancies of the position at any point will be also computed, since it is generally the most important parameter used to estimate the quality of any data. Moreover, the efficiency of the output results will be evaluated by analyzing the root mean square error RMS of the 2D and positional discrepancies at all selected check points for the whole image, since it is the most widely and popular index for error measurements. The distribution of used sixteen check points is shown in Fig. 2.

Fig. 1. Applied test region along with reference ground control points

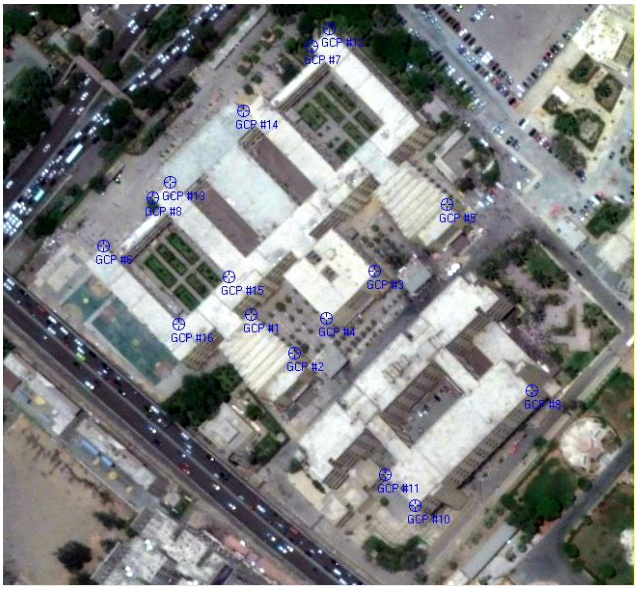


Fig. 2. Distribution of ground check points

III. MESUREMENTS AND RESULTS

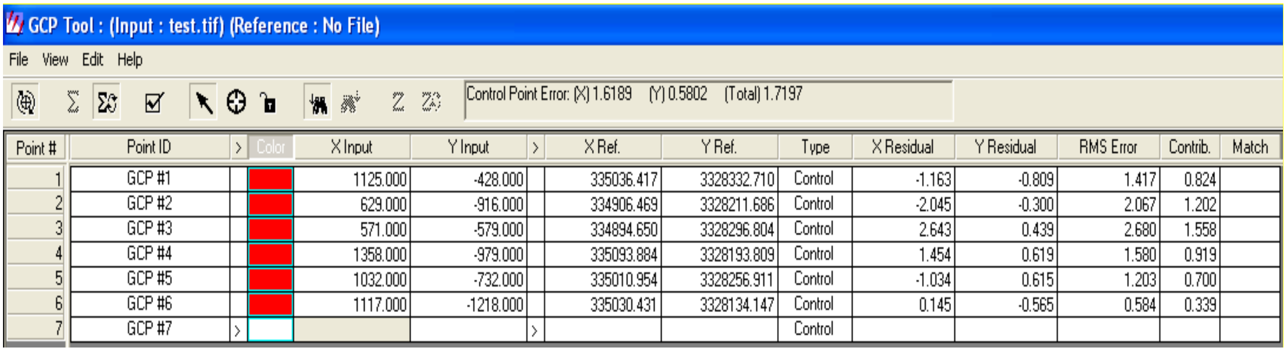
To assess the quality of the captured Google Earth image and then report its corresponding output horizontal accuracy related to the computed georeferenced coordinates, it should be initially tested according to the directly derived coordinates [6]. This requirement entails the verification of the methodology of the current research in order to match within the previous findings. Accordingly, this section is divided into two sub-sections devoted to the positional accuracy of both online and registered images.

A. Google Earth Mapping

Google Earth has undoubtedly become the ultimate source of spatial data and information for private and public decision-support systems and many types and forms of social interactions. However, it must be noted that Google Earth provides this service with a disclaimer that warns users about the quality of the data. Despite this warning, many individuals still refer to Google Earth as a reliable and accurate data source [7]. While inaccuracies in the Google Earth data are not expected to unauthenticated cause harm or damage in many cases, it can potentially cause problems if it is mainly used in technical tasks requiring high accuracy. In this current research, the output discrepancies at all selected check points are listed below in Table 1.

B. Google Earth Georeferencing

The selected Google Earth imagery was processed using ERDAS software for georeferencing, which presents the basic concept of the current research. The total Root Mean Square (RMS) error for the used selected six common control points equals 1.7197 pixels, which leads to a final corresponding total Root Mean Square (RMS) error of 0.430 m, as illustrated in Fig. 3.


GCP Tool : (Input : test.tif) (Reference : No File)

File View Edit Help

Control Point Error: (X) 1.6189 (Y) 0.5802 (Total) 1.7197

Point #	Point ID	>	Color	X Input	Y Input	>	X Ref.	Y Ref.	Type	X Residual	Y Residual	RMS Error	Contrib.	Match
1	GCP #1			1125.000	-428.000		335036.417	3328332.710	Control	-1.163	-0.809	1.417	0.824	
2	GCP #2			629.000	-916.000		334906.469	3328211.686	Control	-2.045	-0.300	2.067	1.202	
3	GCP #3			571.000	-579.000		334894.650	3328296.804	Control	2.643	0.439	2.680	1.558	
4	GCP #4			1358.000	-979.000		335093.884	3328193.809	Control	1.454	0.619	1.580	0.919	
5	GCP #5			1032.000	-732.000		335010.954	3328256.911	Control	-1.034	0.615	1.203	0.700	
6	GCP #6			1117.000	-1218.000		335030.431	3328134.147	Control	0.145	-0.565	0.584	0.339	
7	GCP #7	>				>			Control					

Fig. 3. ERDAS Georeferencing output results

Endeavors to improve the positional accuracy of Google earth imagery in mapping applications is the main motivation behind the current study. Hence, the directly derived coordinates will not be used as a judgment on the corresponding accuracy. With the aid of some common points, Google Earth imagery can be georeferenced again and take its computed coordinates as criteria of positional accuracy assessment. In this context and according to the undertaken methodology, the corresponding output discrepancies at all selected check points are listed below in Table 2.

TABLE I. ONLINE IMAGE DISCREPANCIES

Point No.	Online Image Discrepancies (m)		
	ΔE	*ΔN*	*ΔP*
1	-4.862	-3.316	5.885
2	-5.884	-4.261	7.265
3	-6.016	-6.319	8.725
4	-6.267	-6.021	8.691
5	-8.765	6.453	10.884
6	-8.458	6.650	10.759
7	-8.109	6.826	10.600
8	-7.780	7.244	10.630
9	-12.146	9.919	15.682
10	-11.429	8.317	14.135
11	-8.651	6.514	10.829
12	-8.722	6.767	11.039
13	-7.929	7.396	10.843
14	-8.671	6.602	10.898
15	-7.356	6.027	9.510
16	-7.026	5.607	8.989

TABLE II. REGISTERED IMAGE DISCREPANCIES

Point No.	Registered Image Discrepancies (m)		
	ΔE	*ΔN*	*ΔP*
1	-2.9222	2.2593	3.6937
2	-2.1528	1.2795	2.5044
3	-0.8167	0.2533	0.8550
4	-1.6618	-0.5059	1.7372
5	-2.8826	0.4185	2.9128
6	0.3617	1.1799	1.2341
7	-1.6385	-0.0404	1.6390
8	0.1075	0.4238	0.4372
9	-0.2039	0.1314	0.2426
10	-0.7400	-0.3147	0.8041
11	2.2933	-2.4532	3.3582
12	-1.7707	0.3393	1.8029
13	0.5413	0.9905	1.1287
14	-0.6666	0.0920	0.6729
15	-1.4444	1.0200	1.7683
16	-1.3303	1.6539	2.1225

IV. STATISTICAL ANALYSIS

This section is devoted to the manipulation and analysis of the obtained results, concerning the output measured coordinates from Google Earth imagery. It is quite clear that, comparing both Tables 1 and 2, a significant reduction in the computed coordinate’s discrepancies in both directions is indicated and hence the shifts in position at all selected check points. Again, this reduction is due to the georeferencing of Google Earth imagery using some common control points existing in the interest study area. All statistical parameters of such discrepancies, in both cases of online and registered images, are listed below in Table 3.

Obviously from Table 3, a vast improvement has occurred in all corresponding statistical parameters of output discrepancies. Concerning the Root Mean Square Error (RMS) of such discrepancies, as an accuracy indicator for planimetric coordinates (E, N), it was found to be 10.58m in registered image when compared with its corresponding value of 1.95m in case of online image. This enhancement of planimetric positional accuracy is promising and can be raised under certain conditions and precautions.

TABLE III. PLANIMETRIC POSITIONAL DISCREPANCIES

Google Earth Imagery	Planimetric Positional Discrepancies (m)				
	Minimum Value	*Maximum Value*	*Average Value*	*Standard Deviation*	*Root Mean Square Error*
Online	5.885	15.682	10.335	2.338	10.580
Registered	0.243	3.694	1.682	1.029	1.955

Moreover, and from comparing the measured coordinates in both Google Earth images with the corresponding base ones, there is nearly a systematic displacement at all points. This is assured by taking five directions, each direction connects two of the previously tested check points and forming an edge on a building, to check their lengths and orientations. Fig. 4 shows a schematic diagram showing the orientation of these five edges as drawn in base map and both corresponding Google Earth images.

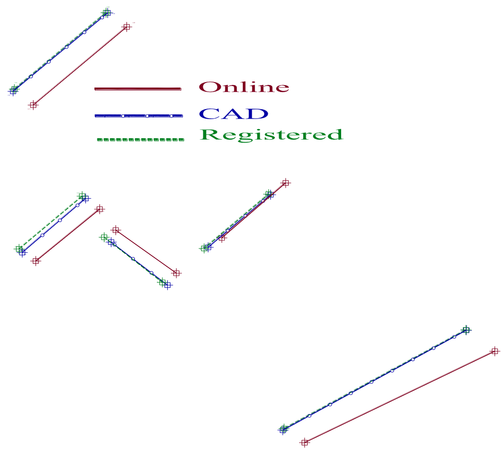


Fig. 4. Schematic diagram showing systematic Line differences

From Fig. 4, one can easily note that, the accuracy of measured distances in Google Earth is considerably better than the accuracy of measured individual coordinates. Also, no significant improvements in the measured distances are remarkable due to the georeferencing of Google Earth imagery, which is easily indicated by comparing the computed discrepancies of both online and registered images. Image registration may have contributed to nearly fixed discrepancies in all tested edges. Finally, the trend of systematic shift in positions is clearly depicted since the orientations of all edges are kept unaltered.

V. CONCLUSIONS AND RECOMMENDATIONS

The ubiquitous Google Earth service is arguably the most well-known and frequently used internet service that provides free-of-charge access to the global collection of satellite imagery. The availability of data that make users in different disciplines use Google Earth in positional data extraction, encourages specialists to carry out researches in order to test and evaluate positional Google Earth extracted data [8]. This research presents an overall assessment of the planimetric positional accuracy of Google Earth imagery in a certain study area. According to the obtained results and analysis, some conclusions can be summarized and enumerated as:

- Horizontal positional accuracy of online Google Earth imagery for a certain study area located in Cairo varies between 5.89m and 15.68m, with RMS value of 10.58m. These findings agreed with many previous studies and investigations, but cannot be generalized to be valid and applicable elsewhere.
- Registration of online Google Earth imagery, within the existence of some control points, enhances significantly Google Earth positional accuracy. This finally leads to a corresponding accuracy of 1.955m. This accuracy can successfully be used to derive planimetric maps with medium and small scales and may be applied in large scales with certain precautions.
- In all cases, the accuracy of measured distances is better than the corresponding accuracy of measured individual coordinates.
- Google Earth imagery has nearly a systematic positional shift. But, in general, 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.
- According to the reached accuracy, the adopted georeferencing methodology can be used for update of maps with medium scale.
- Selection of control points used for processing of images must take into consideration the choice of well-defined sharp points without any shadows to avoid bad identification of points.

As a closing remark, it is highly recommended to perform other studies and investigations concerning the concise evaluation of both horizontal and vertical positional accuracy of Google Earth imagery. These may include the quality and distribution of control points that will increase the accuracy their exterior orientation parameters; approaches of image registration that can include for example fixed constrained distances; and precise field survey verification still remains essential to assess the accuracy.

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