REPORT

Geo-referencing the Satellite Image from Google Earth by Relative and Absolute Positioning

Ghufran Redzwan[1,*] and **Mohammad Firuz Ramli** [2]

[1] Institute of Biological Sciences, Faculty of Science, University of Malaya, 50603 Kuala Lumpur, Malaysia
* ghufran@um.edu.my, + 6 03 79674178 (facsimile) (corresponding author)
[2] Department of Environmental Sciences, Faculty of Environmental Studies, Universiti Putra Malaysia, 43400, Selangor, Malaysia

ABSTRACT   Introduction of geo-visualisation tools over the internet such as Google Earth (GE) has cut down the cost of data acquisition. This study is undertaken to validate the geo-information provided by GE that could be used for geospatial work. Satellite images and latitude-longitude coordinates (X-Y) for the campus of the University of Malaya has been downloaded from the internet. Geo-referencing of the satellite image was carried out using the relative positioning (RP) and absolute positioning (AP) within the geographic information system environment. Sources of X-Y for AP were obtained from GE and a topography map provided by the Malaysian Survey and Mapping Department. For absolute positioning, the data was obtained using GPS equipment. Comparison of these sources was undetaken with the total residual mean square error (RMSE) of X-Y in the map and at the source. All sources of X-Y had produced the total RMSE within 0.00014 degree. Considering the total RMSE as standard deviation (SD), the resulting range of error for geo-referencing of the satellite image was within 15 m. Thus, it can be concluded that geo-information from GE can be used as the source of base map.

ABSTRAK   Dengan adanya perantara visual bagi maklumat mukabumi melalui internet, sebagai contohnya Google Earth (GE), kos perolehan data dapat dikurangkan. Kajian ini dijalankan untuk mengesahkan maklumat ruang bumi daripada GE boleh digunakan untuk kerja ruangan bumi. Imej satelit dan koordinat latitud-longitud (X-Y) bagi kampus Universiti Malaya telah dimuat turun dari internet. Rujukan ruang bumi untuk imej satelit tersebut dibuat dengan menggunakan perisian GIS berdasarkan kepada kedudukan relatif dan kedudukan mutlak. Sumber X-Y bagi kedudukan relatif diperolehi dari GE dan juga daripada peta rujukan oleh Jabatan Ukur dan Pemetaan Malaysia. Manakala bagi kedudukan mutlak, maklumat diperolehi dengan menggunakan peralatan GPS. Perbandingan antara sumber dilakukan dengan pengiraan jumlah ralat min kuasa dua (RMSE) terhadap semua X-Y dari peta dan sumber. Keseluruhan X-Y telah memberikan nilai lingkungan RMSE sebanyak 0.00014 darjah. Dengan menggunakan jumlah RMSE sebagai sisihan piawai (SD), julat ralat yang diperolehi daripada imej satelit yang telah dirujuk ruang adalah dalam lingkungan 15 meter. Oleh itu, dengan nilai SD yang ditunjukkan dalam kajian ini, maka maklumat ruangan bumi daripada GE boleh digunakan sebagai sumber.

INTRODUCTION

Websites which provide geographic information are increasing in an organized manner. This is strongly related to the development of the science of geographic information system (GIS) [1]. Introduction of interactive geo-visualisation tools such as Google Earth (GE) is expected to yield many benefits in terms of communication and participation from the public [2, 3]. It has

introduced the web based platform to visualize geospatial information through simple interface that could be learnt in ten minutes [4]. The image resolution could reach down to 0.60 m [5] and this provides the possibility of utilizing the data for mapping and planning amongst non-cartographers. Relatively, GE gives the geo-information at no cost, which could save a significant amount of the total cost required for the mapping process, which, under normal circumstances, is up to 80% of the total budget [6].

This research was carried out to investigate the accuracy of satellite image from GE in relations to its horizontal positional accuracy. Previous study by Bukvic [7] used the application of GE to determine the location for the assessment and design for urban playground located in Cincinnati, United States of America. However the study did not unveil the GE accuracy that was used. Therefore, this paper attempted to undertake the accuracy assessment of the Malaysian geospatial data from GE imagery. The accuracy values was referred to the standard topography map (1: 10 000), which is published by Malaysia Survey and Mapping Department (JUPEM) [8].

MATERIALS AND METHODS

Satellite image of the University of Malaya (UM) was obtained from GE, which was downloaded as 2.5 m resolution image in JPEG format (Figure 1). In order to achieve the main objective of this study, another map of UM from JUPEM (Figure 2) was referred as well. The image was co-jointed from two pieces of hardcopy topography map [8]. Prior to the combination, the hardcopy of these two maps were scanned by with computer scanner, Hawlett Packard Designjet 815MFB.

Geometric transformation

GE satellite image had been subjected to the geometric transformation according to the given coordinates during geo-referencing. Geo-transformation of the satellite image and topographic map were carried out using

geographic information system (GIS) software, Arc View 9.1 [9]. This transformation provides the direct comparison between the target, which is the satellite image provided by GE with the reference, the topography map by JUPEM. The transformation provides direct input to GIS spatial data [6]. It requires the application of assigned geographical coordinates or also known as ground control point (GCP). In this study, the geo-transformation used both relative positioning (RP) and absolute positioning (AP), referring to three sources of latitude and longitude coordinates (X-Y) for RP provided by GE, and the JUPEM map. The other source global positioning system (GPS) was for AP.

Relative Positioning (RP)

Six well-spread GCPs have been selected for geo-referencing of the satellite image (Figure 1). To obtain the location of features in relation to a geographic coordinate system, the X-Y for the GCPs given by Google Earth were obtained through the same source, Google Earth connection using World Geodetic System 1984 (WGS84) geographic coordinate projection.

For the determination of similar six GCPs for JUPEM map, four GCPs namely, GCP 1a, GCP 2a, GCP 3a and GCP 4a were selected. Those coordinates were selected according to the intersection of latitude and longitude as in the map (Figure 2). The map was then geo-transformed using Geocentric Datum of Malaysia (GDM2000) projection [10], which is similar to WGS84. From the geo-transformed image, the six GCPs were derived. The derivation was done by zoom-in to point in the registered map of Figure 2, in order to determine the GCPs as in the Google Earth imagery. However, GCP 2 was not included in Figure 2 due to the location not clearly portrayed in the topography map.

Absolute Positioning (AP)

Coordinate reading taken from *Garmin e-trex-GPS* with World Geodetic System 1984 (WGS84) as the datum at each of the pre-selected location of the six GCPs in Figure 2.

Figure 1. Satellite Image for the campus of the University of Malaya (downloaded from Google Earth, 2006)

Figure 2. Topography Map of the University of Malaya by JUPEM [8]

RESULTS AND DISCUSSION

Accurate mapping process may not be easy and it is an important aspect of a map. The accuracy assessment undertaken followed the method suggested by US National Standard for Spatial Data Accuracy (NSSDA) to measure and report geographic data quality [11]. The suggested method reflects all uncertainties, including those introduced by geodetic control coordinates, compilation, and final computation of ground coordinate values in the map [12]. The accuracy assessment was carried out according to the degree of conformity of a measurement to its true value [13]. The most widely used measurement is the root mean square error (RMSE) [14]. This measurement has been used by the US NSSDA, which defines RMSE as the square root of the average of the set of squared differences between dataset coordinate values and coordinate values

from an independent source of higher accuracy for identical points (Equation 1). In this study, the independent source of higher accuracy is the JUPEM map. RMSE value can be manually calculated using Equation 1:

$$RMSE_x = \sqrt{\frac{\sum \left(X_{data,i} - X_{check,i}\right)^2}{n}}$$

and

$$RMSE_y = \sqrt{\frac{\sum \left(Y_{data,i} - Y_{check,i}\right)^2}{n}}$$

(Equation 1)

$X_{data, i}; Y_{data, I}$: coordinates of the i th check point in the dataset

$X_{check, i}, Y_{check, i}$: coordinates of the i th check point in the independent source of higher accuracy

N : number of check points tested

i : integer number ranging from 1 to n

Verification of Positioning for Geo-referencing
Minor distortion of the overlays images in Figure 3 indicates that first order polynomials is taking place to model changes in scale, translation, rotation and skew. A minimal irregularity was in

perspective. Curvilinear functions are used to take advantage of the fact that local distortion in some areas varies from the general distortion of the image. These trends can then be integrated into the mapping function, and the image rectified accordingly.

RMSE values were obtained during the geo-transformation of the satellite image that used the designated X-Y coordinates as marked in the both Figures 1 and 2. The X-Y by JUPEM map, GE and GPS are listed in Table 1.

Table 1. X-Y Coordinates for GCPs from RP and AP

GCP	JUPEM Map		GE		GPS	
	X (°E)	Y (°N)	X (°E)	Y (°N)	X (°E)	Y (°N)
1	101.646609	3.128297	101.646472	3.128047	101.646480	3.128120
2	N.A.	N.A.	101.647758	3.121050	101.647919	3.121244
3	101.652363	3.110240	101.652317	3.110061	101.652316	3.109891
4	101.654570	3.119447	101.654378	3.119328	101.654555	3.119325
5	101.662256	3.118930	101.661969	3.118961	101.662390	3.118686
6	101.659210	3.131938	101.659058	3.131939	101.659072	3.132317

Statistically, RMSE is often used to describe accuracy. It includes the difference between the actual GCP in X-Y map with the interpolated test GCP at X-Y source. RMSE is used for geospatial data accuracy requires accuracy on ground distance at 95% confidence level which follows NSSDA standard [11]. The reported accuracy value reflects all uncertainties, including those introduced by geodetic control coordinates, compilation, and final computation of ground coordinate values in the product [12]. It is suggested that a minimum of 20 GCPs should be tested to reflect the geographic area of interest and the distribution of error in the dataset. The 20 points also reflects the 95 % confidence level for the map, considering one data point is allowed to be out of the threshold in the product specification. However, only four GCPs were used in this study as for the primary map source during geo-referencing of JUPEM map. Therefore the maximum accuracy of this study will be at 75% confidence level. Using the perpendular X-Y lines for each GCPs, RMSE for the topography map has been calculated equal to zero. Therefore, geo-referencing of the topography map by JUPEM with four GCPs is statistically acceptable and could be used as the primary source of X-Y coordinates for geo-transformation.

Figure 3 shows the overlaying satellite image onto the topography map. Both overlaid images were registered according to the five GCPs in Figure 2 (JUPEM). Overlaying images shows that geo-referencing of the satellite image was accepted though the level of confidence was increased to 80% by including five GCPs. Similarity for both sources of X-Y coordinates could be explained by the same value of total RMSE for each. Both total RMSE using both RP from coordinates provided by JUPEM and GE gave the value of 0.00014. While geo-referencing the satellite image with X-Y coordinates using AP from GPS gives a slightly lower total RMSE value, which is 0.00011.

RMSE could be utilised similar to standard deviation (SD), therefore it gives the range of error for each source of X-Y. Geo-referencing of X-Y coordinates sources by JUPEM and GE give the value of SD equivalent to 0.504 second for each. Meanwhile, geo-referencing with GPS coordinates gave SD value of 11.8 m. Therefore, the range of error for the geo-referencing of satellite image using X-Y source from JUPEM map and GE give the range of error within 15 m, while GPS as the source of X-Y coordinates give the error within the range of 12 m.
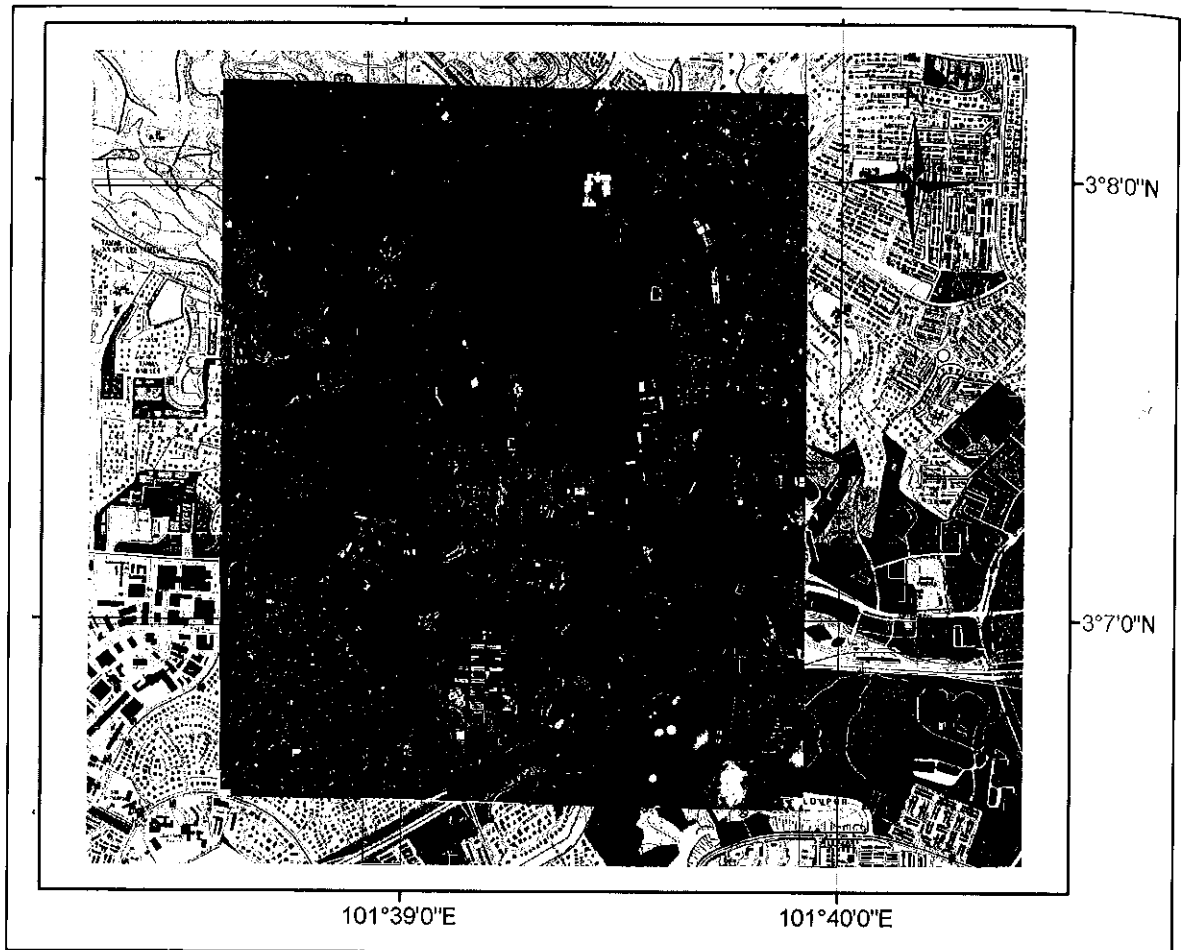
3°8'0"N

3°7'0"N

101°39'0"E   101°40'0"E

Figure 3.   Registered Satellite Images by X-Y coordinates from JUPEM overlays with the topography map

CONCLUSION

Three sources of X-Y coordinates, namely GE, a standard topography map, and GPS are applicable to be used for geo-referencing. All sources produce horizontal accuracy within the range error of 15 m. This study verified that geo-information from GE for the Klang Valley can be used.

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ABBREVIATIONS

AP	: Absolute Positioning
JUPEM	: Malaysia Survey and Mapping Department
GE	: Google Earth
GIS	: Geographic Information System
GPS	: Global Positioning System
RMSE	: Total Residual Mean Square Error
RP	: Relative Positioning
SD	: Standard Deviation
X-Y	: Coordinates for Latitude-Longitude