THE ABILITIES OF QUICKBIRD SATELITE IMAGE IN LARGE SCALE TOPOGRAPHIC MAP UPDATING

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Abstract: The aerial photographs which have been used for updating the large scale topographic map, however, are not very updated for a quickly changing city such as Ha Noi. This study aims to examine the ability of Quick Bird satellite image as an added information source for updating topographic map scale 1:5000. The satellite image dated 2004, after ortho-rectified, has been used in the procedure of digital image processing for topographic map updating to recognized the new features in a map sheet. According to the result of error estimation, the study finds out that: 1. The Quick Bird satellite image can be used as aerial photograph in the procedure of updating topographic map; 2. This method can be applied for the scale 1: 5000 and smaller with satisfying the permitted errors; 3. The updated features should be hydrology network; residential area and vegetation cover. In case of Ha Noi, the Quick Bird satellite data can be used in topographic map updating in period of 2 or 3 years instead of period 5 or 6 years when using the aerial photograph
Keyword: Topographic map update, QuickBird satellite image

1. Introduction

Recently, the digital mapping technology is developed for application of topographic mapping, scale from 1:50,000 up to even 1:2,000. Going with the appearance of high resolution satellite imagery such as IKONOS (spatial resolution maximum 1m); QuickBird (spatial resolution maximum 0.6m), the use of digital mapping technology turn to extract the information from satellite image instead of waiting aerial photograph. The information comes from QuickBird satellite image can be used, and actually used, to update topographic map scale 1: 10,000. This paper aims to ensure that the QuickBird satellite image can be used satisfactorily in updating topographic map scale 1: 5,000.

The Earth surface is change timely. However, the artificial features are rapidly change accompanied with the growing up of economy and especially in a sub-urban area where the urbanization makes the landscape change day by day. We can say that the topographic map of these areas is out of date only after 1 year from published. It requires to determine the oldie of map to have plan of map updating. Normally, the oldie of topographic map is defined by formula (1) and (2) below [1]:

$$Atb = (\Sigma Ai)/n \qquad (1)$$

$$Ai = (B/C)*100\% \qquad (2)$$

Where,
Ai: the oldie of topographic map (percentage),
i: map feature such as residential area, road, land use, etc.,
n: number of map features used in oldie determination
B: the number of change of feature i,
C: total number of feature i.

Simpler, the formula (3) bellows based on the change in square grid can be used also to estimate the oldie of topographic map:

$$P = n1/(n1+n2)*100\% \qquad (3)$$

Where,
P: the oldie of topographic map
n1: number of square grid where the change occurs
n2: number of square grid where no change occurs

The oldie of topographic map then used to plan a period of map updating. Generally speaking, the topographic map scale of 1:5,000 or upper, specially of sub-urban area, has the update period is two (or perhaps three) years. The period of map scale 1:10,000 and lower is longer. Unfortunately, the period of aerial photograph taking in Vietnam is around five years, very much longer than the needs of 1:5000 map updating period. However, the information collected directly from the field may be used to update the map but naturally it takes time and cost. This study used the QuickBird satellite image (spatial resolution 0.6m) to update a topographic map sheet scale 1:5,000. The topographic map is a part of Tu Liem district, Ha Noi, where the change occurs quickly recent years. The accuracy of updating is estimate to point out the ability of QuickBird image in topographic map updating.

2. Study area and materials

Study area

The study area is cover by one topographic map sheet, scale 1: 5000 named: F-48-68-(249). This map sheet covers a part of Tu Liem district where the urbanization occurs quickly with the investment of government for SEAGames 23. The boundary of study area is: form 20^{0} 54’ 05” to 21^{0} 24’ 22”5 North and from 105^{0} 43’ 50” to 106^{0} 01’ 52”5 East.

The study area has flat landscape, absolute elevation from 4m to 6m but it is strong dissected by surface stream. The constructions and new urban area are rapidly developed and map features change monthly. Accompanied, the demands of updated topographic map for new construction areas are urgent. Those are two reasons why the study area is chosen.

Used materials

- Aerial photograph, dated June 2003
- QuickBird image, dated July 2004
- Topographic map sheet, dated January 2004

The software used for satellite image ortho-rectifying is Geomatica 9.1; the software used to update topographic features is Microstation.

3. Methodology

The main steps of using QuickBird satellite image for topographic map updating and accuracy estimation is shown on figure 1.

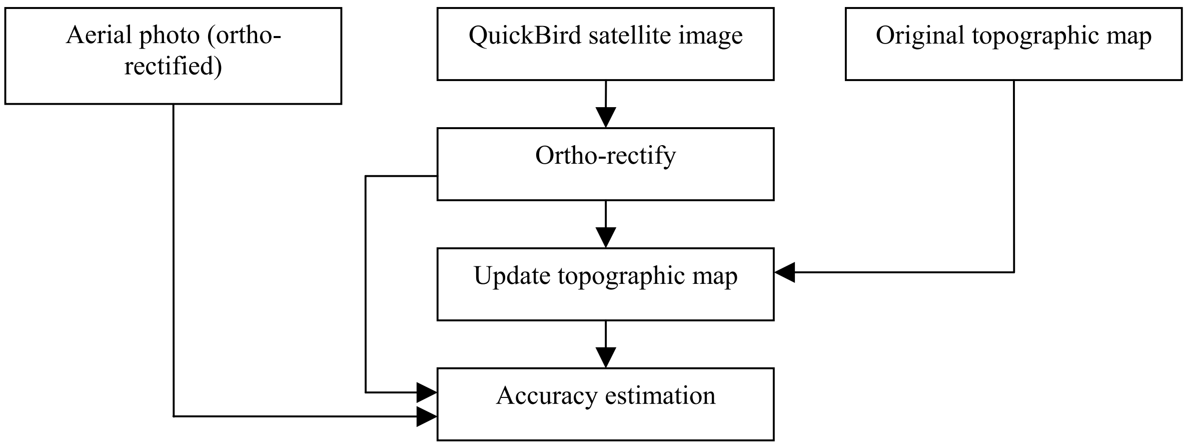

Fig. 1 Main steps of application of QuickBird satellite image for topographic map updating

The satellite image is ortho-rectified by using ground control points collected from the field by APT company. The ground control points have coordinate and altitude determined by high accuracy GPS. The accuracy of ortho-rectifying is smaller than 0.5 pixel (equivalent 0.3m or 0.06mm in the map scale 1:5,000). However, in this study we do not update the altitude which is almost no change in the area and on the other hand, the stereo-pair QuickBird satellite image is not available.

After ortho-rectifying, the satellite image which now becomes image map, has overlaid by original topographic map. By measuring the distance between the features appear in both satellite image map and topographic map, the accuracy is calculated. The original map also overlaid on the aerial photo to calculate the accuracy of if using this product. The accuracies of QuickBird and aerial photo are compared to point out the ability as well as limitation if there is of QuickBird satellite image in topographic map updating.

In case of the accuracy tested of the ortho-rectified satellite image is satisfied the demands of the topographic mapping standard, the new features are recognized visually by comparison the image map and the original topographic map overlaid.

The main task of the process is ortho-rectifying satellite image. It makes the result be usable or not depends on the precision of the ortho-rectification. The accuracy of ortho-rectifying theoretically depends on the: number and distribution of ground control points; accuracy of ground control points themselves, and the distortion of the image.

To increase the precision of the ortho-rectifying process, the high accuracy GPS points have been used. Figure 2 shows the ortho-rectified satellite image while figure 3 shows the ortho-rectified aerial photos.

The aerial photograph normally used to update almost features of topographic map, including elevation. With the QuickBird satellite image, we found that the feature that can be seen changes clearly are:

- Roads;
- River, stream;
- Buildings

Accordingly, only these features are updated on the topographic map. However, these information is quite valuable in the sub-urban area as Tu Liem district. Other information needed in updating process need to be collected in the field (based on the changed feature which found on the satellite image as primary information).

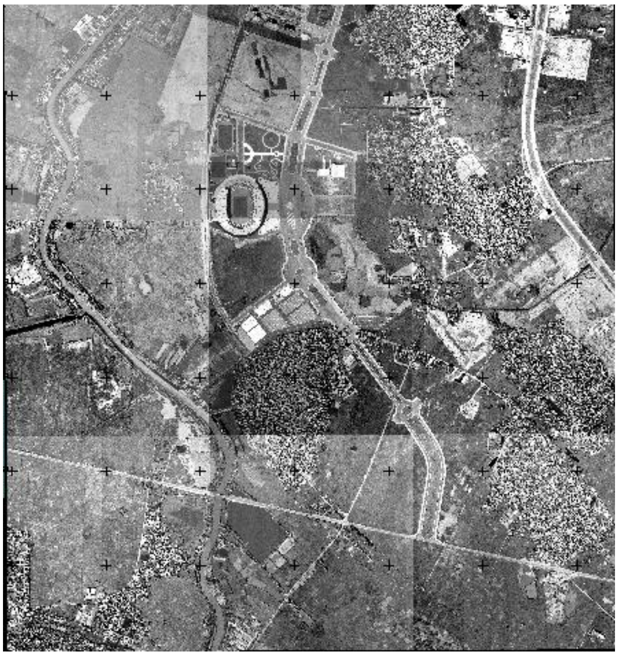

Fig. 2 Ortho-rectified aerial photograph

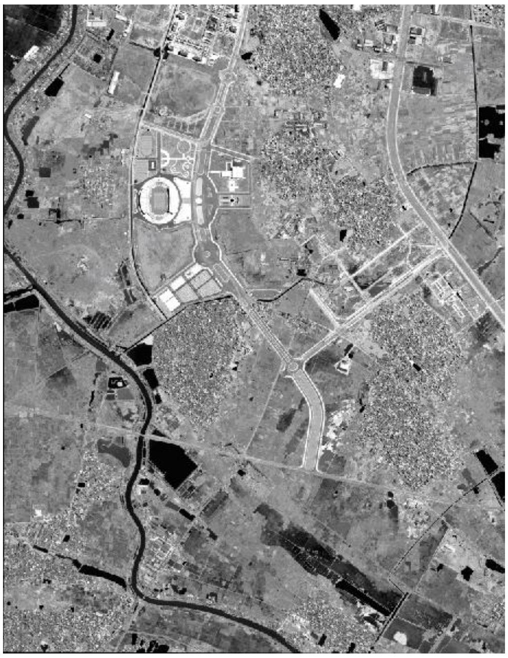

Fig. 3 Ortho-rectified satellite image

4. Result and discussion

Overlaying the topographic map on the ortho-rectified satellite image, the changed features have been recognized visually. Figure 4 shows the updated topographic map.

Based on the GPS points which used as ground control points and tie points for ortho-rectifying of both aerial photos and satellite image, the comparison of aerial photo and satellite image in term of geometric accuracy is calculated by formula (3) and (4):

$$m_{xy} = \sqrt{\frac{\Sigma \Delta_s^{\ 2}}{n}} \qquad (3)$$

$$\Delta_s = \sqrt{\Delta X^2 + \Delta Y^2} \qquad (4)$$

Where, m_{xy} is root mean square error.

With 27 points tested as shown on the table 1, the m_{xy} is calculated equal 0.987m or equivalent to 0.5mm on map scale 1:2000 or 0.2mm on map scale 1:5000.

Fig. 4 Updated topographic map F-48-68-(249)

Table 1. Test points (GPS)

Point ID	Ortho-rectified aerial photo		Ortho-rectified satellite image		Δ_s (m)
	X(m)	Y(m)	X(m)	Y(m)	
16-602-6	578464.782	2325518.337	578464.793	2325518.331	0.012529964
16-602-2	578344.359	2325433.626	578343.046	2325432.629	1.648629128
15-1481-5	578843.97	2325400.627	578843.484	2325401.335	0.858754913
15-1481-4	578888.656	2325850.296	578887.776	2325850.09	0.903789799
15-1481-3	578913.987	2326458.572	578912.999	2326457.991	1.146169708
16-604-1	579329.786	2325776.264	579330.583	2325775.765	0.940324412
15-1479-5	579820.591	2325474.852	579819.592	2325474.839	0.999084581
15-1477-4	580896.468	2325921.701	580896.01	2325922.135	0.630967511
15-1477-5	580812.309	2325386.865	580812.62	2325386.384	0.572784427
16-602-3	578406.141	2324959.601	578406.8	2324958.657	1.151267562
16-602-4	578383.811	2324475.722	578383.324	2324475.014	0.859321244
16-604-2	579461.434	2325324.039	579460.775	2325323.385	0.928437936
16-604-3	579323.145	2324819.071	579323.663	2324819.31	0.57047787
16-604-4	579326.76	2324378.98	579326.984	2324378.384	0.636704013
17-573-1	579140.426	2324234.822	579139.117	2324233.882	1.611546152
17-571-1	580151.335	2324296.2	580151.073	2324296	0.329611893
16-606-4	580225.188	2324304.285	580226.369	2324303.393	1.480008446
17-569-1	581158.728	2324308.958	581158.732	2324307.585	1.373005827
N8079	578494.008	2324071.35	578493.641	2324071.867	0.63401735
16-602-5	578334.421	2323961.84	578333.961	2323962.626	0.91071181
17-575-6	578236.449	2323897.728	578235.015	2323898.935	1.874354556
17-573-2	579145.138	2323828.32	579145.817	2323828.193	0.690774927
16-604-5	579352.527	2323797.238	579353.093	2323797.888	0.861890944
17-573-3	579210.107	2323276.224	579209.941	2323276.818	0.616759272
17-571-2	580192.66	2323843.881	580193.401	2323843.794	0.746089807

16-606-5	580251.786	2323790.907	580252.397	2323790.66	0.659037177
17-569-2	581113.984	2323917.591	581113.804	2323918.179	0.614934143

On the other hand, based on the clear objects found on both aerial photograph and satellite image, the comparison of aerial photo and satellite image in term of geometric accuracy is calculated by formula (5).

$$m_{xy} = \sqrt{\frac{\Sigma\Delta_{GOC}^{\ 2} + \Sigma\Delta_S^{\ 2}}{n}} \qquad (5)$$

While, Δ_{GOC} is reading point error, equal 0.5mm on the map or 2.5m in the field in case of map scale 1:5000. With number of points is 19 (n=19) as listed in table 2, the m_{xy} is calculated equal 1.398m or approximately 0.3mm on map scale 1:5000.

Table 2. Test points (clear objects)

Point ID	Ortho-rectified aerial photo		Ortho-rectified satellite image		Δ_s (m)
	X(m)	Y(m)	X(m)	Y(m)	
1	578487.584	2326092.017	578487.628	2326091.411	0.60759526
2	578378.676	2325961.348	578378.959	2325961.742	0.485103082
3	578504.197	2325630.798	578504.393	2325630.011	0.811039457
4	579546.972	2325818.965	579545.992	2325819.572	1.15275713
5	579264.203	2325695.99	579263.383	2325695.991	0.82000061
6	581049.394	2326078.773	581048.37	2326078.809	1.024632617
7	580779.884	2325587	580779.417	2325587.647	0.797933581
8	578871.384	2324795.003	578872.198	2324794.789	0.841660264
9	578830.607	2325175.996	578830.196	2325175.801	0.454913178
10	579461.005	2324988.195	579460.499	2324987.399	0.943213655
11	579292.338	2324682.13	579292.79	2324682.596	0.649199507
12	580329.521	2324588.294	580330.203	2324587.812	0.835133522
13	580587.065	2325087.086	580587.553	2325087.587	0.699389019
14	78457.474	2323829.069	578456.388	2323830.59	1.86891332
15	578946.387	2323629.597	578947.212	2323630.798	1.45706074
16	579882.462	2323820.652	579882.03	2323820.992	0.549749034
17	579701.469	2323354.734	579702.009	2323355.395	0.853534416
18	580753.07	2323244.024	580753.264	2323242.523	1.513485051
19	580421.979	2323686.633	580422.006	2323685.99	0.643566624

Technically, the first requirement of satellite image in topographic map updating is precision in term of plane as well as elevation. The plane precision in Vietnamese standard is 0.5mm for flat area and 0.7mm for mountainous area. Comparing the precision requires with the GPS points (control points), we find that the QuickBird satellite image satisfies the accuracy of scale 1:5000 and even scale 1:2000.

Comparison of accuracy reached in using GCP and clear-object, we find that using GCP will bring the more accurate result. Accordingly, it is strongly recommended that must use the accurate GPS points as GCP. The clear-object can be used as GCP with less accurate.

In term of topographic map updating, we need information about not only road, river and building but also other map features. So far, these information is not easy to extract from QuickBird satellite image. It is important limitation of satellite image and need to be considered carefully before investment to the image which is still expensive.

5. Conclusions

QuickBird satellite image can be used to update the topographic map scale 1:5000 (or up to scale 1:2000 in case we have enough GPS control points). It meets the requirements of accuracy in standard of Viet nam. The QuickBird satellite image has limitation in some map features, but it is best choice in case of sub-urban area where the urbanization occurs rapidly and displays the changes mostly in roads and buildings.

6. Acknowledgement

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7. References

[1] 1989. *Standards of topographic map updating, scale 1/10.000-1/25.000-1/50.000,* Ministry of Resources and Environment.

[2] 1990. *Standards of topographic mapping, scale 1/ 5.00 - 1/25.000*, Ministry of Resources and Environment.