TEMPLATE IMAGE PREPARATION TO REGISTER THE HIGH RESOLUTION SATELLITE DATA

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ABSTRACT: Template image preparation is a primary requirement in satellite image registration. This technique could be automated by image matching method. Precision of image registration is a tactical goal in remote sensing and geographic information sciences. It could be achieved by applying template image matching method. This experiment described on the preparation of two types of template images. Band ratio normalization is belonged to first type of template creation and simulated image based normalization is second method. Indeed, the study demonstrated that red band ratio could be applied to remove shade and shadow disturbances of satellite images. On the other hand, artistic structures are very good ground objects for ground control point selection because of those structures had consistency to seasonal land cover change.

1. INTRODUCTION

Selection of precise ground control points (GCP) are needed to register satellite images and geographic information data. In reality, there are time and location constraints in collection of GCPs by GPS or manually survey. To avoid those constraints, automatic GCPs collection is interest way to remote sensing scientists. Satellite datasets could be helped to collect GCPs. Even though, sun's illumination affects are the main disturbances to land surface information collection in satellite remote sensing sciences. Firstly, shaded and shadow of images illuminated by sun direction should be removed. Then, the shade/shadow free images could be as target and reference images.

The study describes process and technique of template image preparation, automatic ground control points collection and image registration. In template image preparation, three datasets are calculated based on satellite sensor's multi-spectral bands. There are 13 ground control points are collected from each of calculated reference templates using least squares matching method. In this method matching calculation is iterated until initial input minimized to global optimization. Red ratio normalization pair produced satisfies result when the accuracy is specified to 5 pixels. There are several types of ground features are selected from vegetation, bare land, artistic structures, and forest area. Particularly, artistic structures gave high matching result.

2. STUDY AREA

The area is located downstream of Monobe river of Kochi prefecture in Japan. It covered 6 km x 6 km of river bank regions including hilly, plain area buildup areas. There are three datasets are used in this study two of them are acquired from satellite and other is digital surface model (DSM). Descriptions of satellite datasets are mention (table 1).

Table 1: Satellite images information.

ASTER VNIR (Visible and Near Infra Red)		IKONOS	
BAND	***Wavelength (w/m²/sr/µm)***	***BAND***	***Wavelength (w/m²/sr/µm)***
Band1	0.52 ~ 0.6	Band2	0.506 ~ 0.595
Band2	0.63 ~ 0.69	Band3	0.632 ~ 0.698
Band3N	0.78 ~ 0.86	Band4	0.757 ~ 0.853
Acquired Date/Time	08-Mar-2002 (10:54)	Acquired Date/Time	15-Jun-2000 (10:43)
Spatial Resolution	15 meters	Spatial Resolution	1 meter
Sun Azimuth Angle	149.319783°	Sun Azimuth Angle	114.7576°
Sun Elevation Angle	46.683752°	Sun Elevation Angle	69.25115°

3. METHODOLOGY

The first part of the methodology is image normalization. By applying image normalization, shades and shadows of target ground objects could be simply removed. This removal method is an importance pre-process to least squares matching.

Removal of shade and shadow affect from satellite datasets, selection of GCPs and how distributed they are on overall area, and which transformation methods are main topics in this satellite image registration study.

The study will be applied two methods to remove shade and shadow: band ratio normalization and image simulation.

3.1 Normalization by Removal of Shade and Shadow

First, band ratio method (equation 1, equation 2) is used to remove shade and shadow affects. Study is illustrated that band ratio could be eliminated shades and shadows from satellite images. For comparison purpose, there two ratios are used to demonstrate good result. They are infra-red ratio and red ratio of data (figure 1). Second method included a combination of red ratio and DSM's shade and shadow (equation 3).

InfraRed/(GREEN+RED+InfraRed) Infrared ratio -----*1*

For ASTER: *band 3/ (band 1+ band 2+ band 3N)*

For AKONOS: *band 4/ (band 2+ band 3+ band 4)*

RED/(GREEN+RED+InfraRed) Red ratio -----*2*

For ASTER: *band 2/ (band 1+ band 2+ band 3N)*

For AKONOS: *band 3/ (band 2+band 3+band 4)*

By applying band ratio normalization shade and shadow from respective image were removed. In the case of ASTER image, the study used three bands as two visible and one near infra red. The three spectral wavelengths are ranging from 0.52 μm to 0.86 μm and IKONOS have 0.506 μm to 853μm.

IKONOS Red normalized + DSM relief	ASTER Red band

Figure 1: Band ratio results, ASTER red band and DSM.

In the case of shaded relief, it was created from digital surface model (DSM) data by applying sun vector of target satellite images. Afterwards, those shaded relief image and red ratio image are mathematically added each other to output required target image.

3.2 Normalization by Simulation of Shade and Shadow

DSM (relief) +RED/(GREEN+RED+InfraRed) Red ratio +relief -----*3*

For ASTER: *DSM (relief) + band 2/ (band 1+band 2+ band 3N)*

For AKONOS: *DSM (relief) + band 3/ (band 2+band 3+ band 4)*

A satellite image is simulated by composition of spectral, shade and shadow (figure 2). Spectral of land surface reflectance was collected from reference satellite image by red ratio. Shadow and shaded disturbance of reference image were removed by band ratio normalization. Subsequently, shaded relief image was created from digital elevation model (DSM) data. In this creation, shade and shadow were extracted by giving sun vector of ASTER image to DSM data. The extracted shade and shadow images were added mathematically to get shaded relief image. Finally, shaded relief and red ratio image were added. The calculation produced a simulated target image. I could be match with ASTER's original red band.

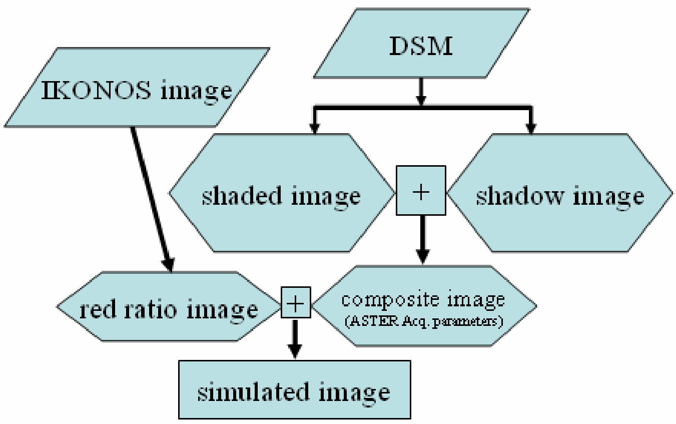

Figure 2: image simulation process chart.

3.3 Selection of GCPs

GCPs are selected by least squares image matching method (equation 4). At first, three set of image templates (figure 3) are created from reference image based on initial conditions/values.

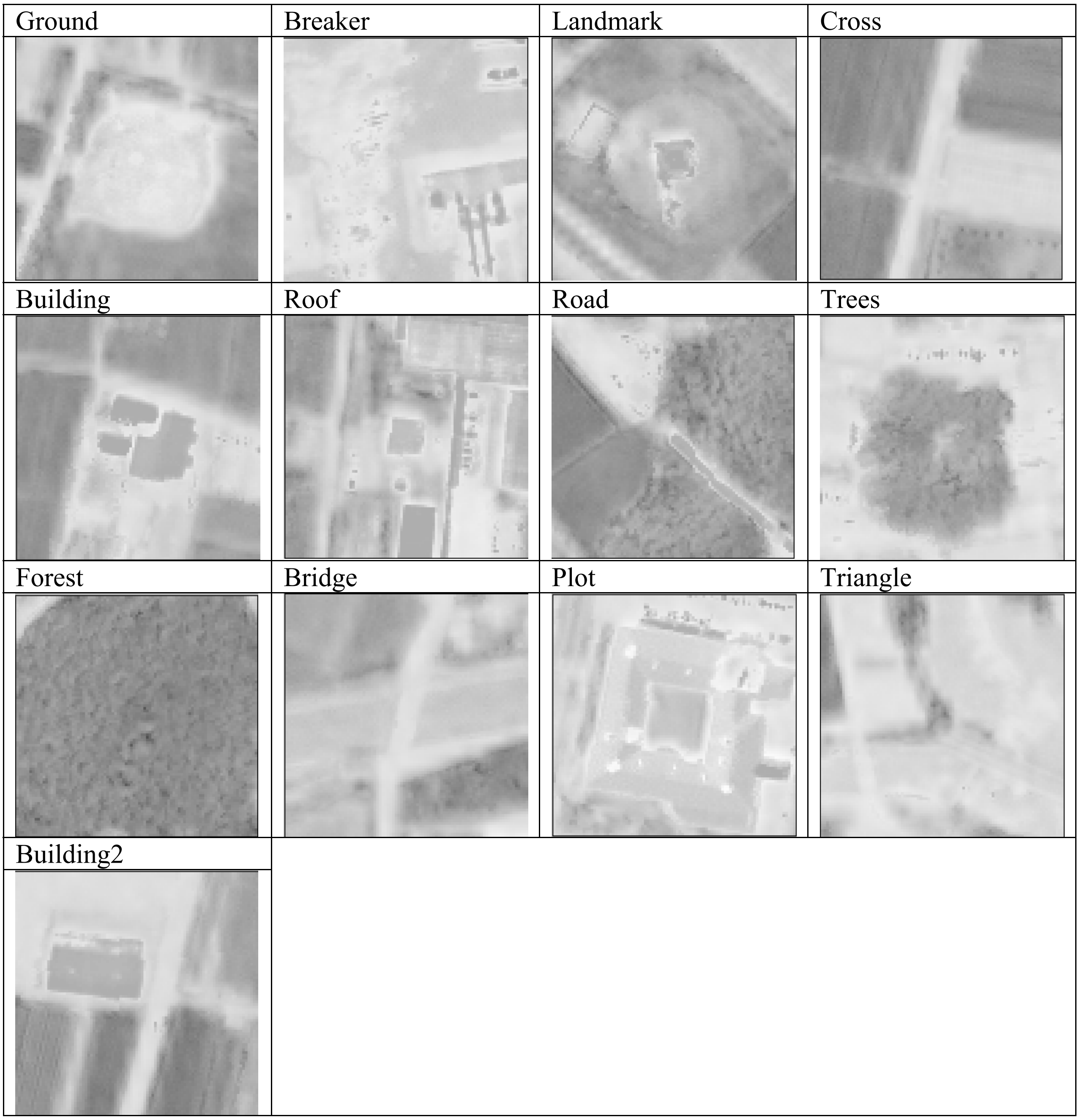

Figure 3: Image templates for red ration plus DSM.

The program searched a matched pair of value from target images and output it as automated selected GCPs.

$$g_t(x,y)=h_0+h_1+g_s\,[(a_0+a_1x+a_2y),(b_0+b_1x+b_2y)] \quad \text{--- 4}$$

where: g_t: target window; g_s: template window; h_0, h_1: unknown coefficients for brightness adjustment; a_0, a_1, a_2, b_0, b_1, b_2: unknown coefficients for geometric transformation

The equation is nonlinear equation; hence the equation was linearized by Taylor series. Initial values for unknowns were input to the linearized equation, and then iterative calculation carried out until the correction of the initial input minimized to be fall in global optimization.

3.4 Registration

There are many transformation methods to do geometry correction such as Helmalt, affine, projective. Apart from other methods, the 3 dimension projective transformation (equation 5) is the best fit to the study area because of the area had hilly area, plains and unevenly distributed buildup area.

$$u = (a_1x + a_2y + a_3z + a_4)/(b_1x + b_2y + b_3z + 1)$$
$$v = (a_5x + a_6y + a_7z + a_8)/(b_1x + b_2y + b_3z + 1) \text{ ------------ } 5$$

where: u, v = image coordinate; x, y, z = ground coordinate and $a_1, a_2, a_3, a_4, a_5, a_6, a_7, a_8, b_1, b_2, b_3$ are unknown coefficients

4. RESULTS

The outputs of least squares matching are listed (table 2). There are 13 features are selected distributing over whole images.

Table 2: Initial values and LSQ output.

				IR ratio		***Red ratio***		***Red ratio + relief***	
ID	**Feature**	**Initial U**	**Initial V**	**u**	**v**	**u**	**v**	**u**	**v**
1	Ground	3845	753	3840.07	754.83	3839.51	757.70	3842.17	764.06
2	Breaker	4276	5505	4261.66	5505.98	4290.60	5498.64	4298.96	5501.91
3	Landmark	2930	5122	2930.84	5127.07	2926.97	5120.82	2929.88	5124.13
4	Cross	427	5579	329.55	5536.22	435.14	5582.86	391.82	5564.46
5	Building	1067	2821	1067.28	2810.31	1068.79	2816.83	1067.61	2809.95
6	Roof	2242	2241	2240.41	2242.89	2240.93	2243.73	2239.94	2243.59
7	Road	5251	3451	5256.98	3456.86	5251.41	3450.67	5241.61	3443.53
8	Trees	4727	4831	4726.59	4821.57	4727.95	4821.50	4726.33	4816.53
9	Forest	2896	3256	1765.39	5805.13	2891.25	3258.09	2996.63	3183.68
10	Bridge	1762	5804	1764.12	5806.04	1767.57	5786.43	1764.12	5806.04
11	Plot	4291	435	4297.91	438.00	4315.10	442.73	4283.42	437.83
12	Triangle	5783	4816	5795.59	4832.39	5796.36	4821.36	5803.22	4815.96
13	Building2	1921	420	1912.59	430.39	1914.93	429.71	2188.18	325.25

5. DISCUSSION

The study observed that it is very difficult to identify the small features such as bridges, road cross sections, houses, trees on ASTER images. It affected to selection initial values. Based on matching results (table 3), red ratio pair gave good result compared with others. It could be concluded that vegetation spectral is highly influence over image matching. Apart from band ratio discussion, the study could be gave some decision based on features. When roof is giving the best control for all matching pairs; breaker, cross, trees, plot, triangle and building2 gave high deviation.

A constrain in the study is influence of land cover changes by acquisition date/time (table 1). Study observed that seasonal land covered meanly affected to matching result of near infrared ratio.

As future work, it could be possible to improve by adding more control points from more ground objects.

Table 3: Deviation of LSQ result from initial values.

ID	Features	*IR ratio*		*Red ratio*		*Red ratio+Relief*	
		Δu	**Δv**	**Δu**	**Δv**	**Δu**	**Δv**
1	Ground	4.93	-1.83	5.49	-4.7	2.83	-11.06
2	Breaker	14.34	-0.98	-14.6	6.36	-22.96	3.09
3	Landmark	-0.84	-5.07	3.03	1.18	0.12	-2.13
4	Cross	97.45	42.78	-8.14	-3.86	35.18	14.54
5	Building	-0.28	10.69	-1.79	4.17	-0.61	11.05
6	Roof	1.59	-1.89	1.07	-2.73	2.06	-2.59
7	Road	-5.98	-5.86	-0.41	0.33	9.39	7.47
8	Trees	0.41	9.43	-0.95	9.5	0.67	14.47
9	Forest	1130.61	-2549.13	4.75	-2.09	-100.63	72.32
10	Bridge	-2.12	-2.04	-5.57	17.57	-2.12	-2.04
11	Plot	-6.91	-3	-24.1	-7.73	7.58	-2.83
12	Triangle	-12.59	-16.39	-13.36	-5.36	-20.22	0.04
13	Building2	8.41	-10.39	6.07	-9.71	-267.18	94.75

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