EFFICIENT ORTHO-RECTIFICATION OF OLD SMALL-SCALE AERIAL PHOTOGRAPHS USING PRISM PRODUCTS IN JAPAN

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ABSTRACT：

Fortunately, in Japan, vertical aerial photographs acquisitions were started since 1940s. Furthermore, 22% of the land has been clearly captured by PRISM until March 2007. To utilize the exuberant archives, this study evaluates how PRISM product works for the automatic ortho-rectification process of the old small scale aerial photographs. First of all, we conducted a static analysis to grasp the overall effects of land change. On the analysis, we tried to a streamlining of the process referring PRISM products. The workflow with PRISM product is considered to be effective for ortho-rectifying of old aerial photographs, especially with a few available references of the past.

1. INTRODUCTION

1.1 Background

Up to date, GIS and photogrammetry technology have achieved a lot of development. And various research and development have been conducted with the technology all over the world. Now no one doubts that automatic time change detection will also come to a reality.

Most of the cases to observe temporal changes on the land, aerial photographs are mainly used. Those photographs are generally acquired at different time, condition and scale. Consequently condition of image archives is always the wild card to plan such projects. We also use satellite images for the purpose. Satellite image dataset on civilian use has been available since the 1990s. Recently many high-resolution satellite images are captured all over the world. However, even now the price is still expensive as it was before.

Problems on archive are most serious especially when it goes in practical use. In reality, a number of the available images and their quality are greatly influenced due to location of the test site and data capturing duration.

1.2 Small-Scaled Images in Japan

Fortunately, in Japan, vertical aerial photographs acquisitions were started since 1940s. The photographs have been provided at reasonable price by the government. In addition, the Advanced Land Observing Satellite (ALOS) was launched in 2006 and 22% of Japanese territory has been captured by its three-line sensor PRISM until March 2007. Concerning to PRISM, highly accurate and automatic processed products (DSM and Ortho image) are prospective with the start of RPC model distribution in April 2007. Those images are very good references to understand national land situation.

During 1955 to 1975 Japan had a high economical growth period. Many topographic changes took place all over the cities

after that period. Almost medium and small cities archive only limited records that describe the changes of the past. To complete these data lack, old aerial photographs are most useful materials. However geometrical rectification of old aerial photographs is very difficult work. It takes a lot of time and effort due to lack of supporting information, e.g. inner orientation and exterior orientation parameters. It is also difficult to collect enough number of GCPs from the existing references.

1.3 Approach for Efficient Ortho-Rectification

This study evaluates how PRISM product works for the automatic ortho-rectification process of old small scale aerial photographs which are used for the mapping of land use and landform changes. To get geo-references for ortho rectification of old aerial photographs, we use Value Added Products of PRISM. Since PRISM products are relatively cheaper and updated frequently, it is readily available as a reference data.

We present the result of an analysis of topographic changes and surviving features within 60 years of temporal changes in a test site. Linear feature extraction method adopted to get geo-referencing information from map sheets, and PRISM imagery.

2. TEST SITE AND MATERIALS

2.1 Test Site

The test site is located on the western side of the metropolitan area at the center of the mainland of Japan. The prefecture has been blessed with a number of the environments, such as: large cities (e.g. Yokohama), medium cities, bay area (e.g. Sagami bay) and mountains. Some of the cities in the prefecture have important historical landmarks and large archive of references. The central part is formed from urbanized plains. Concerning to the western area, there is a large foothill surrounding Mt. Fuji, and 1,500-1,600m high mountains range one after another. Hakone volcanic region is also located in the southwest area.

2.2 Materials

Old aerial photographs, which we used in this study, were acquired during 1946 to 1956 by US forces. These are panchromatic photos at 1/10,000 – 1/40,000 scales. PRISM products (DSM, Ortho images) acquired on XX Jan 2007 were utilized to get references for ortho rectification of old aerial photographs. As a reference for a validation of positional accuracy, 1 /25,000 scale topographic maps provided by Geographical Survey Institute (GSI) were used. GSI has a huge amount of archives, since each map are updated to the latest versions every 10 years at least. Topographic maps were published around 1946. To get land use information and land condition information of the prefecture, we also used Digital Map 5000 (Land Use) and 1/25,000 Scale Land Condition Maps, which are also provided by GSI.
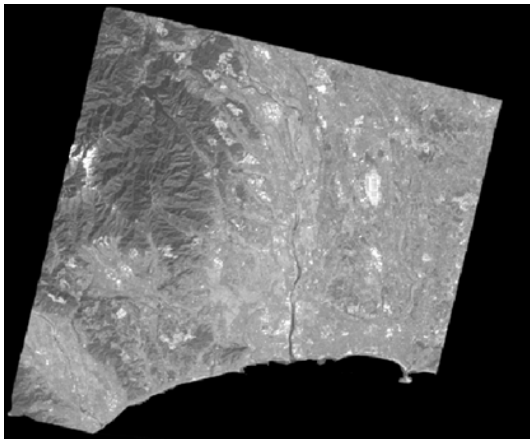

Figure 1. Test site (PRISM ortho image)

3. TREND ANALYSIS OF LAND USE / FORM CHANGE

We sampled some areas to confirm trend of typical land changes in each sites using PRISM products and old aerial photos. Futhermore, we applied thresholds for validating the landform/land use for each area. The analysis helped to simply grasp the overall effects caused by many complex factors. In addition, those changes were detected by visual check.

3.1 Sampled Area

Area 1: Plural small communities connected.

Figure 2. Old aerial photo (1/20,000 15 Aug 1946)

Figure 2. PRISM Ortho Image (31 Jan 2007)

Area 2: The framework is same as before.

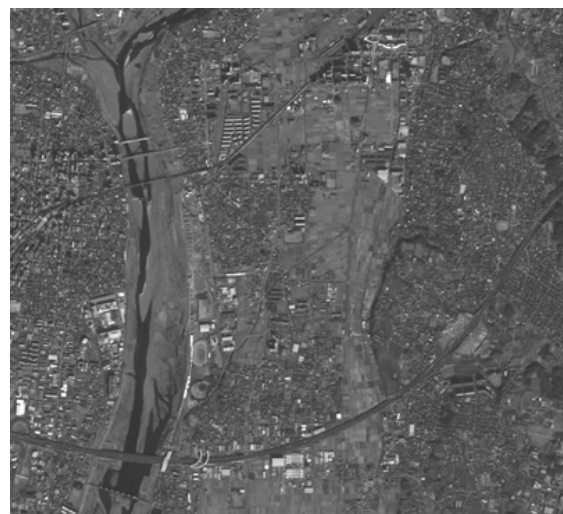Figure 3. Old aerial photo (1/39,921 13 Feb 1948)

Figure 4. PRISM Ortho Image (31 Jan 2007)

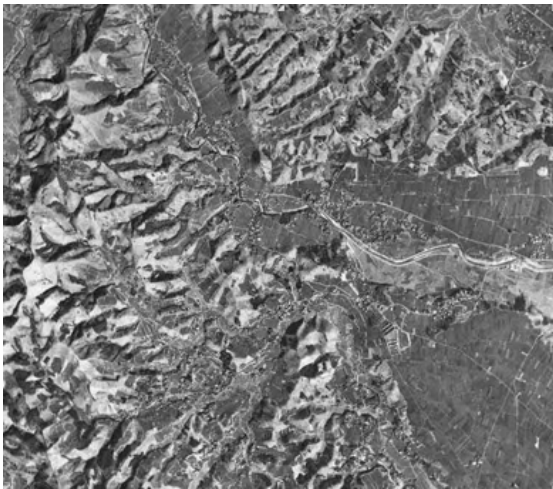**Area 3:** some hilltops were developed.

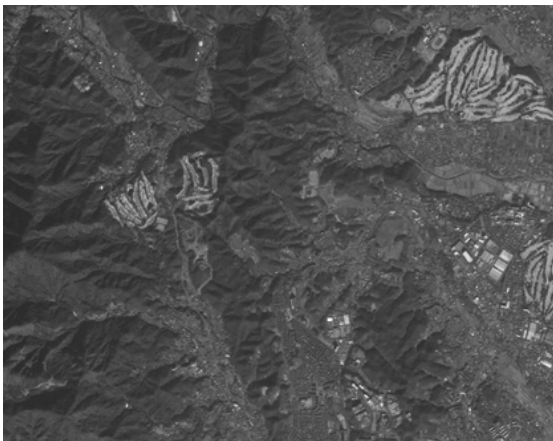Figure 5. Old aerial photo (1/20,132 13 Mar 1956)

Figure 6. PRISM Ortho Image (31 Jan. 2007)
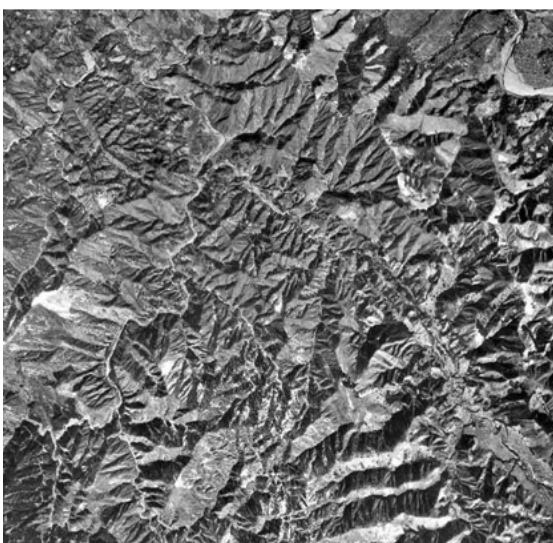
Area 4: A dam was constructed.

Figure 7. Old aerial photo (1/39,610 15 Feb 1948)

Figure 8. PRISM Ortho Image (31 Jan 2007)

3.2 Analysis

In the present study, a numerical classification was conducted to grasp visual information of typical topographic changes in different area. The quantification analysis estimated the below characteristics: basic landform, location and land use and topographic change.

Question	Intensity of Validity				
	1	2	3	4	5
Is area covered with flat land?	No				Yes
Indented?	No				Yes
Elevated?	No				Yes
What is the scale of change? (km^2)	**Less than**	0.1	1	10	**Larger than**
What is the height scale of change? (m)	**Less than**	5	10	15	**Larger than**

Table 1. Sample of threshold

The analysis of the landform change showed that changes caused by human activities were extending along the roads or river basin. The major changes caused by human activities (e.g. construction of new towns etc.) were extended to gradual slopes and hilltops and the terrain changes influenced significantly for geo-rectification. Furthermore, there are some acute changes on steep slopes in mountain regions and were caused by disasters or disaster prevention measures. Especially for all widespread change, it is difficult to recreate the old terrain model from PRISM DTMs automatically, whereas some references about the change were substantially available.

4. ASSISTING FOR THE COLLECTION OF GCPS

Based on the trend analysis, we tried a streamlining for the collection of GCPs. Most common shape of existing features after 60 years is linear shape. And point of intersection of lines is easier to pinpoint the pixel. For this reason, we selected some common points from old and new linear features. Those points

were utilized to do adjustment of camera model as GCPs. Under ordinary circumstances, both old and new features were extracted from the old aerial photos and PRISM's ortho images.
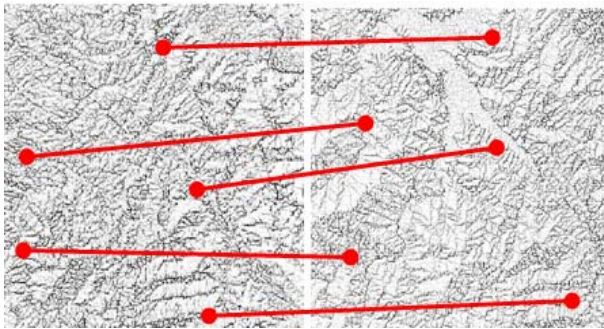
	X	Y	TOTAL
Area 1	1.5439	1.4306	2.1048
Area 4	4.6497	0.5172	4.6783

Table 2. Check point error

Figure 10. Linear Features and Common Points (Area 4)

The reference of linear features is weighted for small change. This is more easily obtainable and more easy-to-use values than other references. Therefore huge development of artificiality has a tendency to trace a part of original feature in Japan.

5. EFFICIENT ORTHO-RECTIFICATION

Finally, based on the above result, we tried a streamlined workflow of ortho-rectification. A result of accuracy validation is shown in Table 2.
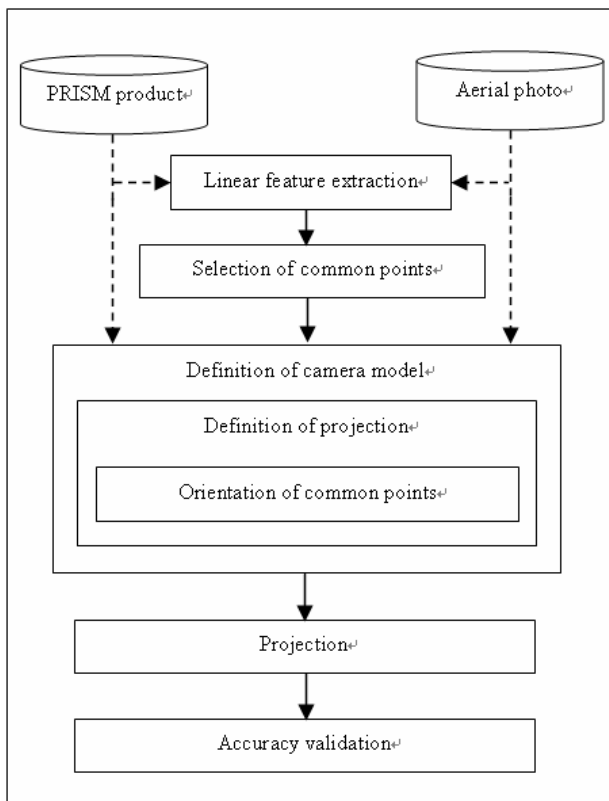

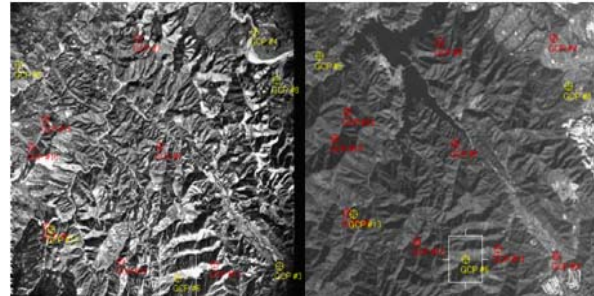Figure 11. Workflow with ERDAS IMAGINE

Figure 12. GCPs and check points (Area 4)

6. CONCLUSION

The mentioned results lead to the conclusion that the use of PRISM products is effective in ortho rectification of old aerial photos, especially for the medium and small cities. However, some rectifications of DTMs are essential around developed hilltops and damaged steep slopes or gullies. For such problems, we will have some rectifications of the terrain model with experimental filtering in the near future. Moreover, full-automation of collection of GPSs also remains. Especially in this case we could not get sufficient information on camera parameters and the flight courses. To utilize the wealth of image archives, we must try to add a feature matching technique that can correspond to rectify the skew of extracted linear features.

REFERENCES

Geographical Survey Institute, Government of Japan, 1995. GIS HOME PAGE, Japan. http://www.gsi.go.jp/ENGLISH/ (accessed 30 Apr 2008)

Remote Sensing Technology Center of JAPAN (RESTEC), 2000. RESTEC, Japan. http://www.restec.or.jp/top_e.html (accessed 30 Apr 2008)