EXTRACTION OF DEBRIS FLOW BY USING REMOTE SENSING IMAGE
- GENERATING ACCURATE ORTHOGONAL IMAGE AND THE UTILIZATION-

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***ABSTRACT*:** In 2004, many debris flows were occurred by typhoon in Shikoku JAPAN. Those debris flows made huge damages in infrastructure. Therefore location of all debris flows must be understand immediately to rescue, control traffic and reduce damages. Remote sensing images less than 1m resolutions or aerial photographs images were expected for extraction of disasters. Therefore, orthogonal image must be converted immediately to extract disasters. The orthogonal image can be compared with other thematic map or existing images. However, it is difficult to convert accurate orthogonal image. The accurate orthogonal image is generated by using geometric transformation equations with accurate control points and accurate surface model. The control point is consist with ground control point (GCP) and corresponded image control point (ICP). Usually, control points were acquired by visual interpretation. When control points were acquired from1:2500 map, the accuracy of generated orthogonal image became poor. Yamakawa (2002) used circle type control points to proceed accurate orthogonal image. However, it is difficult to prepare circle type control points in various fields. Therefore, other types of control point such as polygon of agricultural field should be evaluated.

Objective of this study is establishing an accurate orthogonal image by using polygon type control points. Centroid of polygon in agriculture field will be used as accurate control point. Required accuracy of orthogonal image should be less than a quarter of special resolutions. Required accuracy of GCPs and ICPs should be 1/10 of special resolutions. Accuracy was evaluated by Root Mean Square Error (RMSE) which was calculated around control points and validation points.

GCP polygon data were generated by kinematic survey using GPS. Centroid was calculated by triangurated area and the centroid. The calculated centroids of polygon were used as GCP. ICP polygon image were extracted from the satellite image by visual interpretation. ICP polygon image was binarized for calculating centroid. The calculated centroid of polygons were used as ICP.

Orthogonal image was generated by acquired 15 centroids in polygons. The result showed 0.4 pixel error. It could not be satisfied required accuracy. However, centroid of polygon type was efficient for control points rather than point base control point. After generating orthogonal image, debris flow will be extracted accurately by image classification method.

KEYWORDS: Remote Sensing Image, Geometric correction, Debris Flow

1. INTRODUCTION

1.1. Converting Remote Sensing Image to Orthogonal Image

Currently, remote sensing imageries less than 1m resolutions are used in many fields. Especially, remote sensing imageries are expected to extract disaster. There are two types of remote sensing imageries. One is high-resolution satellite image, another one is aerial photograph. It is necessary to be converted satellite image or aerial photograph to orthogonal image for extraction disaster. Orthogonal image can be converted by using geometrically transformation equations. Generally, affine transform can be applied for high-resolution satellite imageries, and direct linear transform can be applied for aerial photograph. Coefficient of the transformation equations are determined by least square method with coordinates of control point. The control point is consisted with ground control point (GCP) and corresponded image control point (ICP). Either satellite image or aerial photograph, accurate control point is very important.

When required accuracy of orthogonal image is less than quarter of special resolutions, required accuracy of GCPs and ICPs should be 1/10 of spacial resolutions.

1.2. Generating Orthogonal Image from Aerial Photograph using 1:2500 Map

GCPs as point data was acquired from 1:2500 map by visual interpretation. And corresponded ICPs as point data was also acquired from aerial photograph by visual interpretation. Orthogonal image was generated from aerial photograph by acquired control point dataset. However, the result could not satisfy required accuracy. The error showed over 7 pixels error. Because, the accuracy of control point in 1:2500 map was very poor. Therefore, it was difficult to acquire accurate control point from 1:2500 maps by visual interpretation.

Yamakawa (2002) proposed circle type control point to proceed accurate geometric correction. However, it is difficult to prepare circle type control point in various fields. Therefore, other types of control point such as polygon of agricultural field should be evaluated.

2. OBJECTIVES

Objective of this study is establishing an accurate orthogonal image by using polygon type control points. Centroid of polygon in agriculture field will be used as accurate control point. GCP was acquired from polygon data by kinematic survey using GPS. ICP was acquired by remote sensing image from the corresponded GCP polygons.

Required accuracy of orthogonal image is less than a quarter of special resolutions. Required accuracy of GCPs and ICPs should be 1/10 of special resolutions.

Accuracy was evaluated by Root Mean Square Error (RMSE) which was calculated around control points and validation points.

3. DATA USED

In this study, IKONOS was used as remote sensing image. It was the digital-geo image which was corrected distortion by the roundness of the earth. IKONOS have 1m spacial resolutions. Table 3.1 shows the specification of used IKONOS imagery. Test area was selected around Tosayamada-cho, KOCHI prefecture, JAPAN (Fig 3.1). The Image was covered about 11km x 11km. There were several small towns, deep forest, wide river, many farm lands, port and few buildings.

Table 3.1 Specification of Used IKONOS

Item	Detail
Cross Scan	0.86m
Along Scan	0.84m
Scan Direction	0 °
Nominal Collection Azimuth	263.9600 °
Nominal Collection Elevation	76.68608 °
Acquisition Data/Time	2000/6/15
Photography Area	Tosayamada Kochi JAPAN
Area (km^2)	134.848
Product Level	Digital-Geo Image
Sensor Type	Pan-Sharpen (4 Bands)
Map Projective Method	Transverse Mercator
Ellipsoid	Bessel
Datum	Tokyo

Fig 3.1 Test Area, IKONOS

4. ESTABLISHMENT OF CONTROL POINT DATABASE USING CENTROID OF POLYGON

4.1. Ground Control Point

GCP polygon data were generated by kinematic survey using GPS. Centroid of polygon was calculated by consisted many small triangles and the centroid. Figure4.1 showed calculation flow of the centroid. Figure4.2 showed example of surveying points and the calculated triangle for acquisition of GCP. Following equations can be used for centroid calculation.

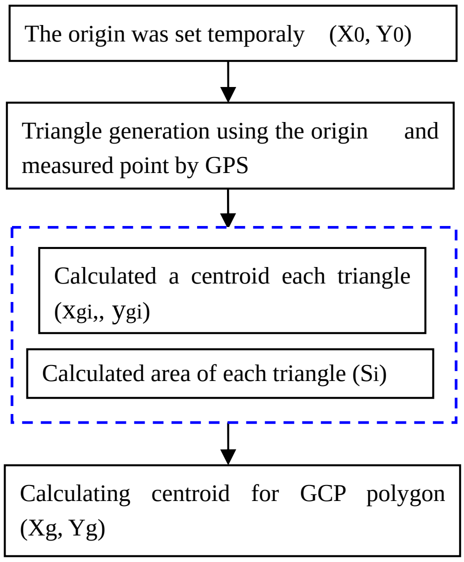

Fig4.1 Flow chart
-Calculation method of centroid-

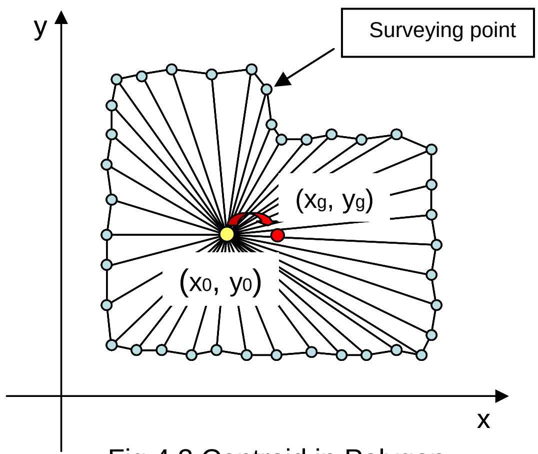

Fig 4.2 Centroid in Polygon

$$Xg = X_0 + \sum_{i=1}^{n} S_i \times (x_{gi} - X_0) / \sum_{i=1}^{n} S_i$$
$$Yg = Y_0 + \sum_{i=1}^{n} S_i \times (y_{gi} - Y_0) / \sum_{i=1}^{n} S_i \qquad (4.1)$$

(Xg, Yg) : Centroid
$(X0, Y0)$: Temploraly origin
(Xgi, ygi) : Centroid in each triangle
Si: Area of each triangle
n: Number of triangles

The calculated centroids of polygon were used as GCP. Then, error of GCP by field surveying will be decrease by calculating centroid of the polygon.

4.2. Image Control Point

ICP polygon image were extracted from the IKONOS image by visual interpretation. ICP polygon image was binarized for calculating centroid (Fig 4.3). The calculated centroids of polygon were used as ICP. Centroid was calculated average of all coordinates in GCP polygon image by following equations.

$$Ug = \sum_{i=1}^{n} U_i / n \qquad Vg = \sum_{i=1}^{n} V_i / n \qquad (4.2)$$

(Ug, Vg) : Centroid
(Ui, Vi) : Image coordinate
n: number of pixel

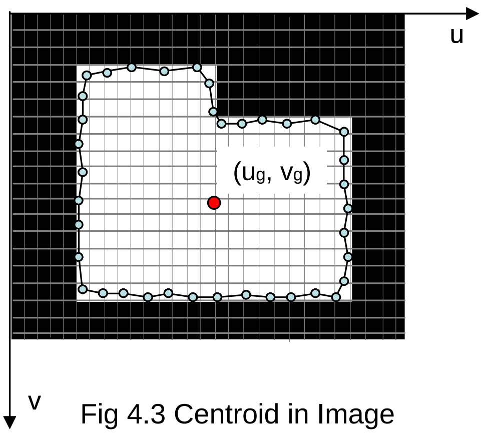

Fig 4.3 Centroid in Image

5. ORTHOGONAL IMAGE GENERATION

In this study, IKONOS image was used as remote sensing image. Therefore, geometric transformation was selected affine transform as follows;

$$u = a_1 x + a_2 y + a_3 z + a_4 \qquad v = b_1 x + b_2 y + b_3 z + b_4 \qquad (5.1)$$

u, v = ICP
x, y, z = GCP
$a_1 \sim a_4$, = Transformed coefficient
$b_1 \sim b_4$ = Transformed coefficient

In this study, 15 polygons were acquired for generating orthogonal image. Fig 5.1 showed spacial distribution of polygons. Fig 5.2 showed example of polygon data.

Fig 5.1 Spatial distribution of control polygon

Fig 5.2 Acquisition of control point polygon

Orthogonal image was generated by acquired centroid in polygon. The number of acquired control points were 15 points: 8 points were used for actual control and 7 points were used for validation. Table 5.1 showed error of orthogonal image using centroid in polygon. The result showed 0.4 pixel errors were remained. Fig 5.3 showed error vectors of control point using centroid in polygon.

Table 5.2 showed error of orthogonal image using conventional control points which were point base data. The number of acquired control point were 35 points: 8 points were used for actual control points and 27 points were used for validation. The result showed almost 1.0 pixel errors were remained.

Centroid of polygon was efficient for control points rather than point base data.

Table 5.1 Error of orthogonal image using centroid in polygon

RMSE (pixel)	u	v
Control Point	0.298	0.159
Validation point	0.349	0.230

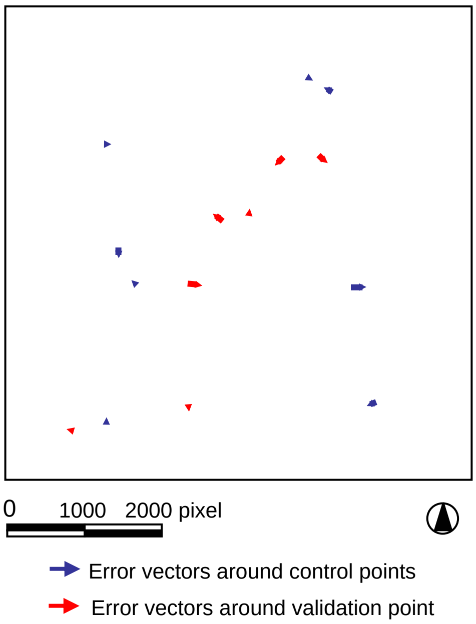

Fig 5.3 Error Vectors of control point using centroid in polygon

Table 5.2 Error of orthogonal image using point database

RMSE (pixel)	u	v
Control Point	0.908	0.267
Validation point	0.869	0.501

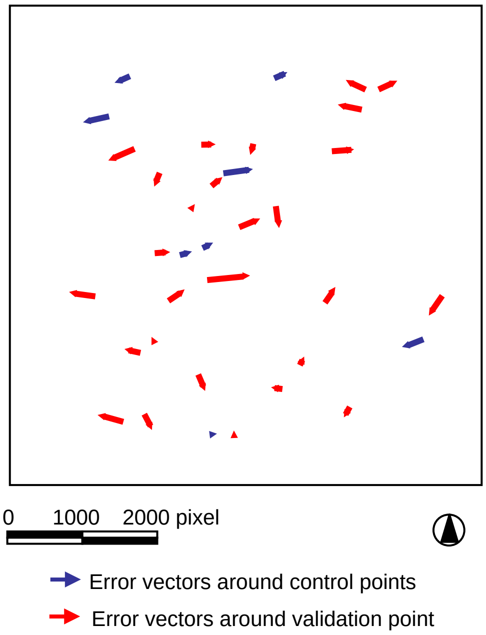

Fig 5.3 Error Vectors of control point using point database

6. CONCLUSION

In this study, an accurate orthogonal image generation was established by using polygon type control points. Centroid of polygon in agriculture field was used as accurate control point. IKONOS image was selected for generating orthogonal image by using affine transform. RMSE around control point showed less than 0.4 pixel. The result could not be satisfied required accuracy. However, centroid of polygon was efficient for control points rather than point database.

Fig 6.1 showed aerial photographs which was taken before disaster in Ehime prefecture. Fig 6.2 showed generated orthogonal image by using direct linear transform from aerial photograph which was taken after disaster in same location. The aerial photographs have 0.25m spacial resolutions. The orthogonal image was generated from control point of point database. Because polygon base control points were not prepared. The result showed error was remained 27.5 pixels error around control points. The error around validation points showed 49.7 pixels error. They were very bad accuracy.

When polygon base control points are prepared, accurate orthogonal image will be generated. And, automatic extraction of debris flow disaster will be possible by using image classification.

Fig 6.1 Before disaster image

Fig 6.2 After disaster image

7. REFERENCE

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