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AN IMPROVEMENT IN EDUCATIONAL TOOLS FOR GEOMETRIC CORRECTION OF SATELLITE IMAGES BY USING DEM WITH SHADE SIMULATION

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ABSTRACT: When carrying out the geometric correction of the satellite image, referring to a map, selection of the ground control point (GCP) between a map and a satellite image serves as very difficult work for a beginner. Moreover, the precision of selection of GCP differs depending on a skill, and the precision of geometric correction differs personally. On the other hand, when choosing GCP between images, visual information is much helpful, and a beginner can also perform geometric correction precisely. This paper compares the case where geometric correction is performed between DEM (Digital Elevation Model) image with a shade simulated based on the reaction of the solar light at the time of an observation and satellite image with the case where geometric correction is performed between a map and a satellite image. From the analyses, it is shown that geometric correction for a mountainous region can be performed with a higher precision using a shade simulated DEM image than a map.

1. INTRODUCTION

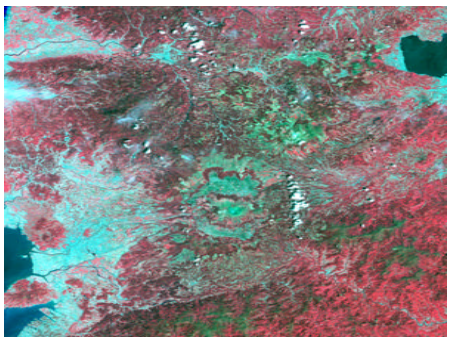
The geometric correction is very important task to start on the analyzing of satellite data. The selection of the GCP, however, between a satellite image and a map serves as very difficult work for a beginner (Iikura, 1998). Moreover, the precision of selection of GCP differs depending on a skill, and the precision of geometric correction differs personally. On the other hand, when choosing GCP between images, visual information is much helpful, and a beginner can also perform geometric correction precisely. In this paper, the case where geometric correction is performed between DEM (Digital Elevation Model) image with a shade simulated based on the reaction of the solar light at the time of an observation and satellite image with the case where geometric correction is performed between a map and a satellite image will be compared and the residual errors of both cases will be investigated.

2. TEST DATA

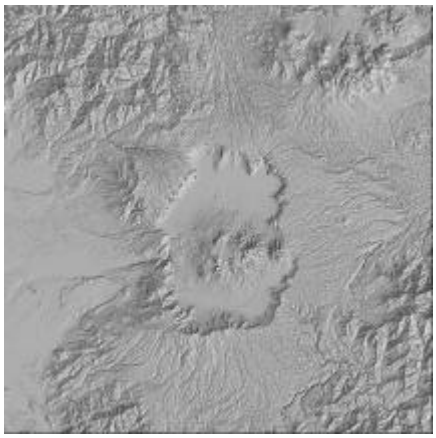
In this study, two areas are selected as test site of geometric correction. One is the area of a mountainous region around Mt. Aso, the other is that of an urban area around Hiroshima city in Japan. As the satellite data, five Landsat-7 ETM+ (Enhanced Thematic Mapper Plus) data are used listed in Table 1. Also digital maps (1:25,000) distributed by Geographical Survey Institute (GSI) of Japan with CD-ROM around the test site as a reference and DEM data (50m mesh) distributed by GSI of Japan with CD-ROM as a shade simulation are used. The geometric correction is performed with the function of IMAGINE Version 8.4 on UNIX a machine and the residual errors of geometric correction for X axis, Y axis and total are calculated with this function. As the geometric correction between a reference image and object image, 1st order polynomial formula is used.

Table 1. Test data for geometric correction.

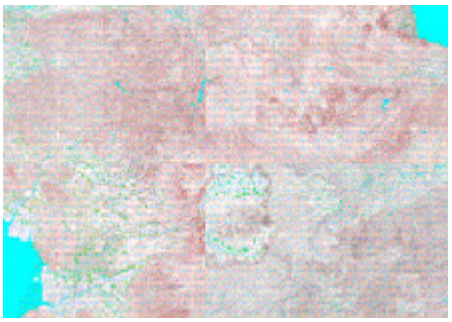
Satellite	Place Name	Path – Row	Observation Date	Observation Time in UTC	Angles of Sun	
					Azimuth	Elevation
Landsat-7 ETM+	Mt. Aso	112 – 037	03 May 2000	01:39:47	127.6	62.4
Landsat-7 ETM+	Hiroshima	112 – 036	01 Apr. 2000	01:39:38	137.9	52.6
Landsat-7 ETM+	Hiroshima	112 – 036	22 Jul. 2000	01:38:27	116.6	63.7
Landsat-7 ETM+	Hiroshima	112 – 036	24 Sep. 2000	01:37:34	145.5	49.4
Landsat-7 ETM+	Hiroshima	112 - 036	30 Jan. 2000	01:37:37	149.5	31.8



(a) Landsat-7 ETM+ on 01 May 2000



(b) DEM DEM (Date: 01 May, Time: 01:39:47 UTC)

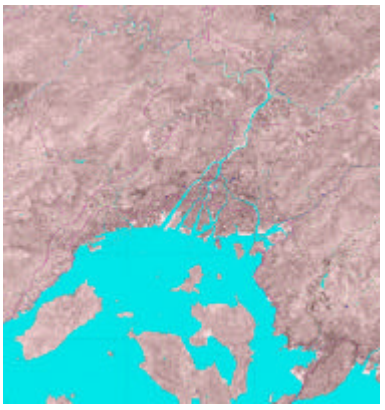


(c) Digital Map (1:25000)

Figure 1. Test data for a mountainous region around Mt. Aso in Japan.

(a) Landsat-7 ETM+ on 01 April 2000

(b) DEM (Date: 01 April, Time: 01:39:38 UTC)



(c) Digital Map (1:25000)

Figure 2. Test data for an urban area around Hiroshima city in Japan.

Table 2. Residual Errors of Geometric Correction for Mt. Aso of Landsat-7 ETM+ Data (01 May, 2000) with Digital Map and DEM Image.

	Experience	For Digital MAP				For DEM Image			
		GCP	Error X	Error Y	Error Total	GCP	Error X	Error Y	Error Total
Student A	1 year	22	2.4350	1.5795	2.9024	21	1.2810	1.0516	1.6582
Student B	1 year	23	1.7330	1.5721	2.3398	21	1.5237	1.4238	2.0854
Student C	2 years	25	1.6550	1.0900	1.9817	20	0.8972	1.1302	1.4430

Table 3. Residual Errors of Geometric Correction for Hiroshima Data of Landsat-7 ETM+ Data (01 Apr. 2000) with Digital Map and DEM Image.

	Experience	For Digital MAP				For DEM Image			
		GCP	Error X	Error Y	Error Total	GCP	Error X	Error Y	Error Total
Student A	1 year	24	0.7898	1.0937	1.3491	24	0.7544	2.1723	2.995
Student B	1 year	24	0.6212	0.5597	0.8362	25	1.1777	0.7654	1.4046
Student C	1 year	28	0.7047	0.6110	0.9327	25	1.2446	1.1970	1.7268

Table 4. Residual Errors of Geometric Correction for Hiroshima Data of Landsat-7 ETM+ Data (22 Jul., 2000) with Digital Map and DEM Image.

	Experience	For Digital MAP				For DEM Image			
		GCP	Error X	Error Y	Error Total	GCP	Error X	Error Y	Error Total
Student A	1 year	25	0.7431	0.6847	1.0104	25	1.4812	2.9520	3.3027
Student B	1 year	24	0.8320	1.4368	1.6603	25	1.1616	1.0270	1.5505
Student C	2 years	25	0.6804	0.4104	0.7946	25	0.8226	0.5751	1.0037

Table 5. Residual Errors of Geometric Correction for Hiroshima Data of Landsat-7 ETM+ Data (24 Sep., 2000) with Digital Map and DEM Image.

	Experience	For Digital MAP				For DEM Image			
		GCP	Error X	Error Y	Error Total	GCP	Error X	Error Y	Error Total
Student A	1 year	21	0.7614	0.8172	1.1169	19	2.1398	1.6206	2.6842
Student B	1 year	24	1.6820	1.5760	2.3049	24	2.5930	1.5279	3.0096

Table 6. Residual Errors of Geometric Correction for Hiroshima Data of Landsat-7 ETM+ Data (30 Jan., 2001) with Digital Map and DEM Image.

	Experience	For Digital MAP				For DEM Image			
		GCP	Error X	Error Y	Error Total	GCP	Error X	Error Y	Error Total
Student A	1 year	27	1.7924	1.1774	2.5242	23	1.3864	1.1080	1.7748
Student B	1 year	23	0.7234	1.1919	1.3924	25	1.5749	2.1269	2.6465

3. EXPERIMANTAL RESULTS

The results of the residual errors of the case where geometric correction is performed between digital map and satellite image, and that of the case where geometric correction is performed between satellite data and DEM image with a shade simulated based on the reaction of the solar light at the time of an observation and satellite image are shown in Table 2 – Table 6. For the case of a mountainous region around Mt. Aso shown in Table 2, the residual errors for some beginners who have experience within one year are reduced using simulated DEM image than digital map. From the hearings for beginners, it is found that they performed with the crests and ridges of mountain as the referenced GCPs for the case of mountain regions. On the other hand, for the cases of an urban area around Hiroshima city shown in Table 3 – Table 6, the residual errors for two beginners who have experience within one year are reduced using simulated DEM image than digital map although seven beginners are increased the errors. From the hearings for beginners, it is found that they performed with the bridges, roads and coastlines as the referenced GCPs for the case of urban area. In the shade simulated DEM image, the bridges and roads cannot display and also the location of coastlines have a large errors since the spatial resolution of DEM is 50m. This is a reason that the residual errors for the case of urban area are increased for beginners.

4. CONCLUSION

In this study, the case where geometric correction is performed between DEM images with a shade simulated based on the reaction of the solar light at the time of an observation and satellite image with the case where geometric correction is performed between a map and a satellite image was compared and the residual errors of both cases was investigated. From the analyses, it is found that the beginner can be performed the geometric correction for a mountainous region with a higher precision using a shade simulated DEM image than a map. On the other hand, the bridges and roads cannot display in the shade simulated DEM image and also the locations of coastlines have a large error since the spatial resolution of DEM is 50m. In the feature works, the residual error of geometric correction for the case of overlapped shade simulated DEM image with digital map will be investigate.

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