An Automatic Method of Geometric Correction for Landsat Image using GCP Chip Database

Tae-Hyun Hwang, YoungBo Yun, Geun-Won Yoon, Jong-Hyun Park
Spatial Information Technology Center
Electronics and Telecommunications Research Institute
161 Gajeong-dong, Yusong-Gu, Daejeon, 305-350, KOREA
{hth63339, yyb63484, gwyoon, jhp}@etri.re.kr

Abstract: Satellite images are utilized for various purposes and many people are concerned about them. But it is necessary to process geometric correction for using of satellite images. However, common user regards geometric correction, which is basic preprocessing for satellite image, as laborious job. Therefore we should provide an automatic geometric correction method for Landsat image using GCP chip database. The GCP chip database is the collection of pieces of images with geo-information and is provided by XML web service. More specifically, XML web service enables common users to easily use our GCP chip database for their own geometric correcting applications.
Keywords: Geometric correction, GCP, XML Web service

1. Introduction

It is indispensable to do process of geometric correction because satellite images have geometric distortion against applying in various purpose. However, geometric correction, which is basic preprocessing for satellite image, is a tedious and labor-intensive job. To overcome the limitation, a method of using Ground Control Point (GCP) chip has been introduced in the literature[1][2][3]. However, selecting appropriate GCP chip also requires much efforts and cost. Therefore, we provide an automatic geometric correction method for Landsat image using GCP chip database in this paper.

This paper addresses the method of 1) acquisition of GCPs from a set of Landsat satellite images; 2) construction of the GCP chip database; and 3) process of GCP chip matching and geo-metric correction. In brief, we can acquire GCPs using property of landsat's nadir-viewing, not from geo-referenced images but from raw satellite images. And we add the geographical coordinates on them for GCP chip database, and process geometric correction using block matching algorithm with GCP chip passed by XML web service.

2. Geometric Correction Service

1) GCP Chip

GCP Chip is a small image that has reference coordinates and invariant feature distinctly according to temporal changes in position and brightness. GCP Chip has the following advantages. First, there is no troublesome process, that is, extraction GCPs from digital map, paper map and satellite image. Second, because GCP Chip is not vector composed of lines and points but data type of new (no geocoding) satellite image, it makes GCP extraction more accurate and fast. Third, when GCP information is constructed as database in data archiving center (i.e., a lots of data), it presents convenient environment to users in reducing repetitive process. And A few previous publications dealt with an automatic geometric correction using GCP Chip. There is GCP Chip applied to KITSAT-3 (Lee et al., 1998), SPOT (Kim et al., 2002), RADARSAT (Adair, 1996) in previous study[1][2][3][4].

2) Construction of GCP Chip Database

The GCP chip database is constructed using 1:25,000 topographic maps over the Korean peninsula in our project. And we carried out experiments with Landsat-7 ETM+ panchromatic band image with 15m spatial resolution. We aimed that GCP information is extracted and a GCP Chip is generated from reference images in this study.

To construct GCP chip database is done by 3 steps as follows. First step, GCP chip information such as geometric coordinates is gathered from 1:25,000 topographic maps over the Korean peninsula. We directly used the GCP information from the result of development work for Landsat MSS/TM image geometric correction and mosaicing. The amount of GCP information is 3~40 points of every Landsat scenes and we used 7 sets of Landsat images (one set has 21 pieces of Landsat MSS images or 25 pieces of Landsat TM image and can cover Korean peninsula)[5].

Second step, we make image chips from reference satellite images that are not geometrically corrected. As user selects rectangular area from reference image, GCP chip is generated. And user selects GCP point from reference image and fills in width and height of chip. Finally, user can also generate a GCP chip through filling out GCP coordinates and row/column of pixel manually.

In the last step, a generated GCP Chip is stored with patch image and related information in database. GCP chip has lots of information for automatic geometric correction like Landsat's path, row, image coordinates and so on. Fig.1 shows some of GCP chip information and its sample. One of GCP chip has information of image chip size, geo-coordinates of reference image, pixel coordinates and so on.

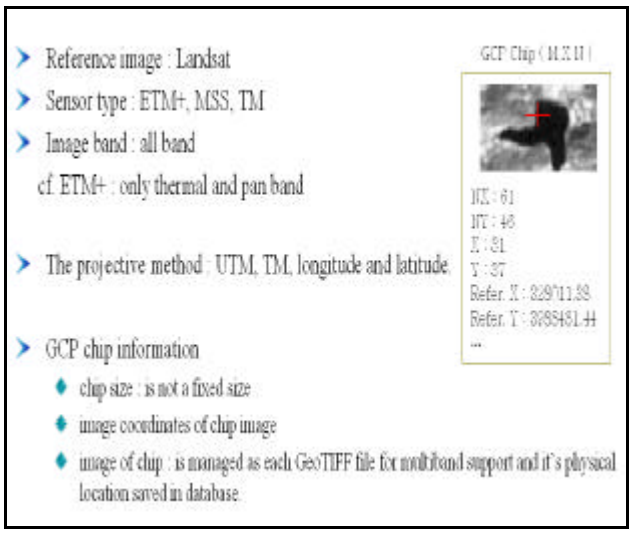

Fig. 1. GCP chip information and GCP chip sample.

When data archiving center (Electronics and Telecommunications Research Institute manages to operate Korea Satellite Imagery Information Management Center called SIMC[6]) presents GCP Chip database through web service, people will have convenient operation environments in geometric correction.

3) Using XML Web Service

Why should we offer GCP chip service with XML web service? The answer is simple. Because we want to help for whoever want to get a their own geometric correcting application like ours and XML web service is a web service paradigm recently. And there is another GCP chip offering service such as offering whole GCP chip database by web-download or off-line service, but we are restricted to offer full information of GCP to common people though Internet service according to the law in force at present. To give an example, we cannot open information including geometric coordinates and images at the same time though Internet. Hence we have to reduce the open information of GCP chips to the minimum just as geometric correction can be possible.

The interaction of GCP chip offering server and automatic geometric correcting client is as follows. And Fig.2 shows the whole steps of interaction of server and client for exchanging GCP chip information.

Step 1: Client sends input Landsat data information to server.
- Landsat image's path, row, band, etc.

Step 2: Server sends information of GCP chips that have same path and row to client.
- GCP chip ID
- Coordinates of GCP chip
- Offset points of GCP chip
- GCP chip image's download URL, etc.

Step 3: Client sends GCP chip Information used in GCP selection process.
- GCP chips ID, matching point, etc.

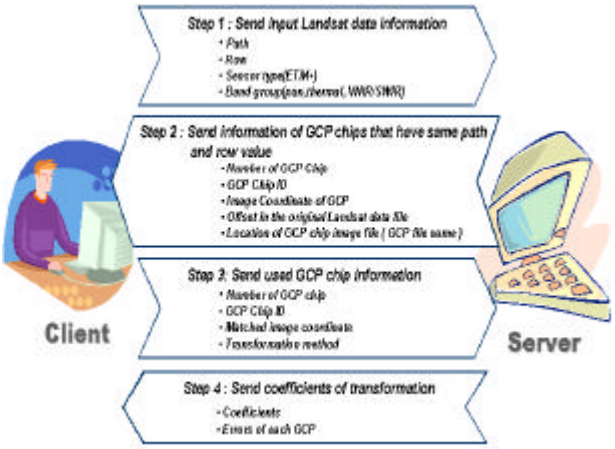

Fig. 2. The whole steps of interaction of server and client for exchanging GCP chip information.

Step 4: Server sends coefficients of transformation for resampling image to client.
- Transform coefficients, error, etc.

3. Implementation

We set up two purposes of developing automatic geometric correcting application. One is to offer easy user interface for common people as well as experts in remote sensing area. The other is to create GCPs automatically for geometric correction from GCP chip database.

We have constructed GCP chip database with 668 pieces of GCP chip images, and the amount of database corresponds to 1 set of Landsat images. We will construct GCP chip database completely including other 7 sets of Landsat image data and offer them in our SIMC web site at the end of this year.

Fig. 3. shows the flowchart of automatic geometric correction for Landsat images using XML web service. The special feature of this system is an open GCP chip database. Whoever wants to use our GCP chip database can access our GCP chip database through XML web service. Moreover GCP chip database will be updated continuously during our site offerring new Landsat images.

Fig. 4. shows the implemented application and a geometrically corrected image. The implemented application shows the one of GCP chip image, its information and geometric corrected image.

The main process of proposed method is described as follows.

1. Load input image as Landsat ETM+.
   - GeoTIFF file type for input image.
2. GCP automatic selection through XML web service.
   - Download GCP chip and its information.
   - GeoTIFF file type for GCP chip image.
3. Select resampling transform method.
   - Using normalized cross-correlation for matching.
4. Save output image to GeoTIFF image file.
   - A coordinate system: UTM

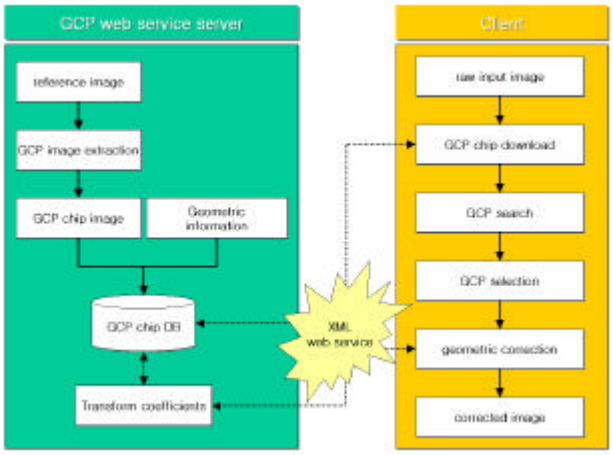

Fig. 3. Flowchart of automatic geometric correction for Landsat images using XML web service.

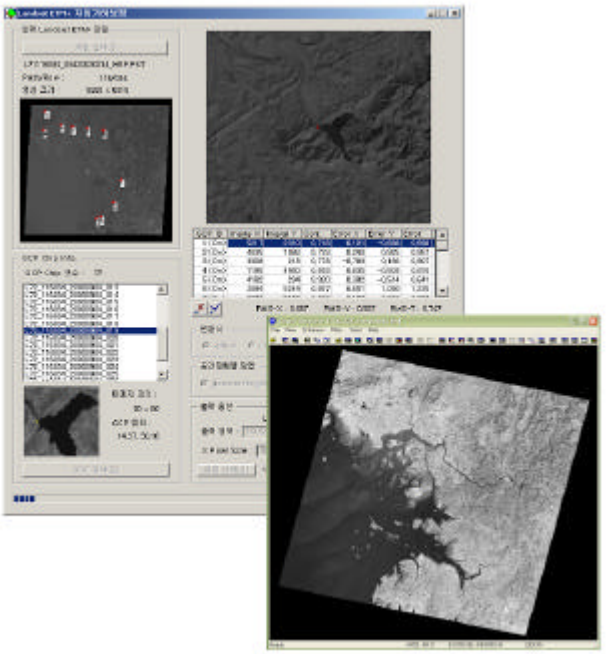

Fig. 4. Implementation and geometrically corrected image.

Table 1. shows the accuracy of our application. The accuracy of geometric correction using area-matching method is better than that using feature-matching, and the count of GCP chip is important factor to reduce errors. Therefore our application is designed to process geometric correction excluding GCP chip data have lots of error. Table 2. shows that the accuracy of geometric correction with GCP chip is similar to traditional method that user selects GCP manually with GCP sets.

Table 1. Accuracy of geometric correction errors related to GCP chip selection count and matching methods.
(unit : meter)

Number of GCP chip	Edge-based matching		Area-based matching	
	X error	Y error	X error	Y error
11	12.8989668	33.3190585	19.9729085	26.0847303
20	7.8317807	17.1001361	14.3842798	7.07515671
31	17.9141196	25.437377	16.0309083	8.14725521

Table 2. Accuracy of geometric correction errors related to the acquired date of GCP chip source image.
(using Area-matching, 13 GCP chips)

Acquired date	RMS X	RMS Y	RMS Total	GCP source
1999.09.27	0.666	0.984	1.188	GCP chip
1999.09.27	0.718	0.978	1.213	GCP sets
2000.10.15	1.295	1.065	1.677	GCP chip
2000.10.15	1.097	0.809	1.363	GCP sets

4. Conclusions

Geometric correction is a critical step to remove geometric distortions in satellite images. For good geometric correction, GCPs have to be chosen carefully to guarantee the quality of corrected satellite images.

In this paper, we present an automatic approach for geometric correction by constructing GCP chip database that is a collection of pieces of images with geometric information. The GCP chip database is constructed by exploiting Landsat's nadir-viewing property. The constructed GCP chip database is combined with a simple block-matching algorithm for efficient GCP matching. This approach reduces time and energy for tedious manual geometric correction and promotes usage of Landsat images.

In near future, to match GCP chip image and new image, we have studied on several algorithms for fast and precise result.

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