Using ASTER Satellite Imagery to Extract DEM

Naomi Wu
RITI Technology Inc.
16F, No. 716, Chung-Cheng Road, Chung-Ho City, Taipei Hsien, Taiwan
annchen@mail.riti.com.tw

Rubia Chen
RITI Technology Inc.
16F, No. 716, Chung-Cheng Road, Chung-Ho City, Taipei Hsien, Taiwan
annchen@mail.riti.com.tw

ABSTRACT

In the past, it has always been time-consuming and labor intensive to extract and update Digital Elevation Model (DEM). How to extract highly accurate DEM with efficiently and the most economical method has always been a cutting-edge topic in the remote sensing filed. This paper discusses using PCI Geomatica OrthoEngine software to extract DEM automatically from ASTER stereo satellite images (15 m resolution). For the study, DEMs were extracted for two sites in Taiwan, and the resulting DEMs were found to have RMS errors between 10 and 16 meters in both flat and mountainous areas.

Keywords: Digital Elevation Model (DEM), ASTER stereo satellite images, PCI Geomatica OrthoEngine

1. INTRODUCTION

There are many ways to extract DEM, but how to acquire accurate the data efficiently and rapidly has always been a main topic being discussed and researched over the years. This paper focuses on the DEM extractions from ASTER satellite images using PCI Geomatica OrthoEngine software and the extracted DEM accuracy assessment.

2. ASTER

ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) is an imaging sensor equipped on the Terra spacecraft that was launched in the December of 1999[1]. The release of ASTER to public has 2 significant impacts for 2 reasons:

1. ASTER is part of NASA's EOS (Earth Observation System) project for the research purpose; therefore, images covering the United States are free and it costs $60 USD per scene outside the United States. As a result, this allows users to save money for data acquisitions[2] (Toutin and Chen, 2001).
2. The VNIR subsystem within the ASTER instrument is designed to have nadir-and backward-looking telescopes. There are three CCD (Bands 1, 2, and 3N) on the focal plane of the nadir telescope, whereas the backward telescope has only one (Band 3B). Simultaneous acquisitions of stereo satellite images within the instrument (along-track) reduce radiometric variations and increase the accuracy of the extracted DEMs;

furthermore, this can reduce the cost to acquire stereo images[3].

3. DATA USED AND IMAGE PROGCESSING

The data used in this research is Level 1 ASTER images, and each scene covers an area of 60kms by 60kms[4]. Two test images are being selected for testing and comparisons: 1) Changhua and Yunlin county (coastal gentle plain,); and 2) Chai and Nantou county (mountainous areas, around Mt. Alishan).

In this research, PCI Geomatica OrthoEngine (a software product developed by PCI Geomatics) is used to extract DTMs for testing. The geometric model utilized here is “Rigorous Parametric Model”, developed by Dr. Thierry Toutin from Canada Center for Remote Sensing (CCRS). Prior to the DEM extraction, the bands 3N and 3B inside the raw ASTER the raw ASTER data are read into OrthoEngine as a pair of the stereo images first, and then Ground-Control-Points (GCPs) and Tie Points (TPs) are collected between the 2 images. Using Rigorous Parametric Model with the collected GCPs and TPs, OrthoEngine generates a pair of “quasi-epipolar images,” and calculates elevation parallax in one direction. The calculated parallax (or location disparity) derived from the terrain relief is used to extract the relative DEM automatically, which is then is being changed to the absolute elevation values with a specified input of the minimum and maximum elevation values in OrthoEngine[5]

4. RESULT ANALYSIS

1. Result

Prioro to the DEM extractions, stereo GCPs and Tie Points are collected for both stereo pair images. For study site 1, the average RMS value of the stereo GCPS is 1.21 and the Maximum RMS is 2.03; whereas study site 2, the average RMS is 1.85 and the Maximum RMS is 3.26. After the automatic DEM extraction, PCI OrthoEngine generates a report (see Table 1) showing the residual errors of the extracted DEM. There are 2 parts in the report. as Part 1 indicates what the minimum and maximum elevation values specified in OrthoEngine to get an approximate elevation space range for the DEM extraction. Part 2 shows the correlation and residual errors of the DEM extraction for each study area.

Table 1: The generated report of the automatic DEM extraction

	Study site 1: flat surface are	**Study site 2: mountain terrain area**
Part 1: Min and Max elevations specified	Min elevation value: 0m Max elevation value: 1300m	Min elevation value: 30m Max elevation value: 3600m
Part 2: Summary report of the DEM extractin in OrthoEngine	DEM correlation success: 77% No of GCP collected: 17 RMS errors: 10.6m Average error: 2.4m	DEM correlation success: 95.6% No of GCP collected: 10 RMS errors: 16.8m Average error: -7.6m

2. Accuracy Assessment

The current Taiwan official DEM was used as the reference for a comparison with the extracted one. Since the current Taiwan DEM has errors along the coastal lines and missing parts and the extracted ASTER DEMs have errors due to the cloud and water presence, 2 cloud-free test sites (with a size of 3km by 3km) are selected at the problem-free areas in the Taiwan DEM for the comparison. The evaluation method used is to generate 30,000 random points in both test areas, and then calculate the elevation difference of at each random point between the 2 DEM. The statistical parameters were calculated as in Table 2.

Table 2: Statistical analysis of the elevation differences at the flat surface area

	Test area 1: flat surface area	**Test area 2: mountain terrain area**
Statistical analysis for the DEM elevation difference values	Mean value: -13.40m 72% of the difference: within 21m 90% of the difference: within 27m	Mean value: -10.574m 70% of the difference: within 45m 85% of the difference: within 69m

5. DISCUSSION AND CONCLUSION

Table 1 shows promising results as the RMS errors for the extracted DEM are 10.6 m (flat surface area) and 16.8 m (mountain terrain area), and the average error is 2.4 m and –7.6 m respectively. Table 2 has the elevation difference mean values for –13.40 m for the flat surface area (study site 1) and –10.574 m for the mountain terrain area (study site 2). 2 kinds of factors may influence the extracted DEM accuracy and the accuracy assessment, as provided: 1) **Factors affecting the accuracy of the extracted DEM:** accuracy of the collected GCPs and Tie Points; distribution and coverage of cloud and snow; distributions of building and vegetation; and finally minimum and maximum elevation values specified as inputs in OrthoEngine. 2) **Factors affecting the statistical analysis of the DEM accuracy:** terrain deformation (911 Earthquake in Taiwan) and the incomplete of the reference DEM.

Nevertheless, inexpensive satellite stereo data such as ASTER with large coverage areas can be an alternative for DEM extraction using minimal labor and time consumption, especially if there is a need to update and acquire DEM information in the near-real time of disaster emergency.

6. REFERENCES

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