ASSESSMENT AND ANALYSIS OF DEM ACCURACY GENERATED FROM SPOT-5 HRS IMAGERY

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ABSTRACT:

SPOT-5 is the first satellite of the SPOT family with along-track stereo imaging capability. HRS(High Resolution Stereocopy), carried on SPOT-5, is the first high-resolution sensor on the SPOT constellation that enables the acquisition of stereo images in push room mode from two different directions along the trajectory. DEM can be generated from the HRS stereo scenes. In this paper, we get the DEM and orthoimage of Baoji, China from SPOTIMAGE Company. We acquire 67 check points from 1:50,000 topographic map, and get the matching points, interpolating elevation. Then, compare the points separately in entire region, flat region and mountain region. The following document presents the result of comparisons and assessment. Using the image model that we have built, we analysis the source and distribution of the precision.

1.INTRODUCTION

SPOT-5 was launched on 4th May, 2002 by Arianespace from the Kourou Space Centre in French Guyana. After completing two months of in-orbit tests it became fully operational in July 2002. SPOT-5 belongs to the SPOT (Satellite Pour l'Observation de la Terre) constellation developed by CNES (Centre National D'Etudes Spatiales). The constellation consists of 3 operational satellites (SPOT-2, SPOT-4 and SPOT-5) flying along a near polar, near-circular and Sun-synchronous orbit at a mean altitude of 832 km, an inclination of 98.7 degrees and a mean revolution period equal to 101.4 minutes. The SPOT satellites orbit the same ground track every 26 days with a nominal cycle of 369 revolutions and cross the equator from North to South at 10:30 a.m. mean local solar time. Within the constellation, SPOT-5 is the most innovative satellite. The new HRG (High Resolution Geometry) instruments, derived from the HRVIR instrument on SPOT-4 offer high resolution in across-track direction with up to 2.5m resolution in panchromatic mode. Moreover the new HRS (High Resolution Sensor) scenes are acquired under the satellite track with a swath 120 width(1200 detector * 10 meters resolution) Look directions of telescopes are +20° (fore view) and -20° (aft view). Forward and backward acquisitions cannot be performed at the same time. As a consequence, the maximum stereo segment that can be acquired is a little bit more than 600 km. Other payload packages include the same Vegetation instrument as on SPOT-4, and the DORIS instrument, for greater orbital accuracy.

Reference3D is produced from the High Resolution Stereoscopic (HRS) tool of the SPOT 5 satellite, and has 3 components:

(1)The Digital Elevation Model (DEM), providing altitudes on a matrix basis, with the following specifications:

- sampling step: 30 meters (about 1'arc at the equator)

- Absolute accuracy in altitude: 10 meters @ 90% for a slope less than 20%

- Relative accuracy in altitude: 5 meters @ 90% for a slope less than 20%

(2) The orthoimage with an excellent accuracy in positioning:

- absolute plan metric accuracy: 16 meters @ 90%

- sampling step: 5 meters (1/6 1'arc at the equator)

(3)Regular quality and traceability.

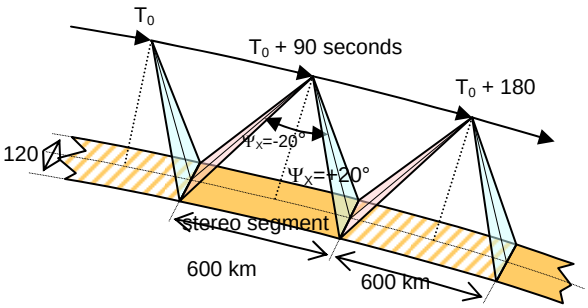


Figure 1. SPOT-5/HRS along-track image acquisition

2.DATA

We get the test data from SPOT Image Company, consisting of: three pairs stereo images from SPOT5-HRS sensor with corresponding metadata files and reference DEMs. The stereo images were acquired on 23rd September 2003 over in Baoji, China. Each image is 12000*12000 pixels large, with a ground resolution of 10m across and 5m along the flight direction. The scenes were acquired in panchromatic mode in stereo viewing along the flight direction with a base over height ration of 0.8. The scenes cover an area with hilly and mountainous terrain. After some process, we get a mosaic image , longitude 104° ~105° , latitude 34° ～35° (figure 2, the black line is the mosaic area).The height difference is 2500m in this area.

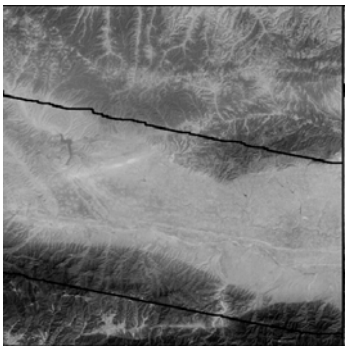


Figure2: Mosaic Stereo Images

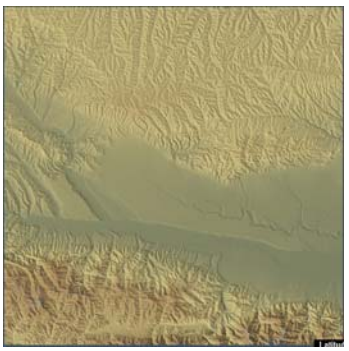


Figure3: Reference DEM

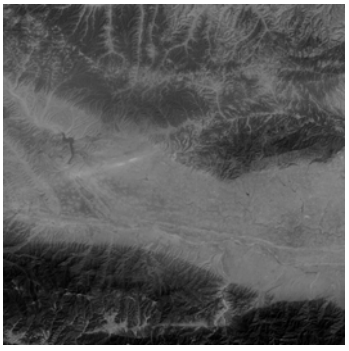
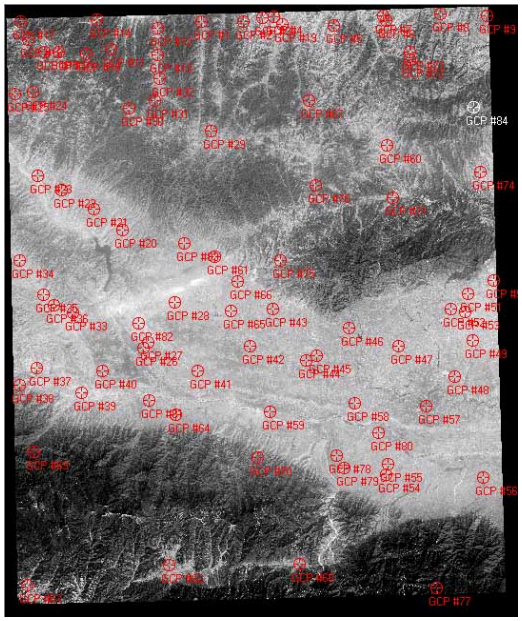


Figure4: Ortho image

3 ACCURACY TEST

We acquire 67 check points from 1:50,000 topographic map, and get the matching points, interpolating elevation.(figure 5). Compare and obtain the accuracy result(Table 1). The plan RMS is 50.03666367m and the height error is 7.864m. The height is good. But the plan RMS is bad. Because the coordinate system used in the topographic map is Beijing 54 coordinate system. And the coordinate system used in reference DEM is WGS84. Compare all matching points, we find there is a regular difference in X direction and Y direction respectively.

The difference of X direction is 45.7023643m, and the difference of Y direction is 20.37060649m. We think this error of as the difference between the two systems. If we eliminate the error, we get the new compare accuracy (figure 6), the accuracy is improved..



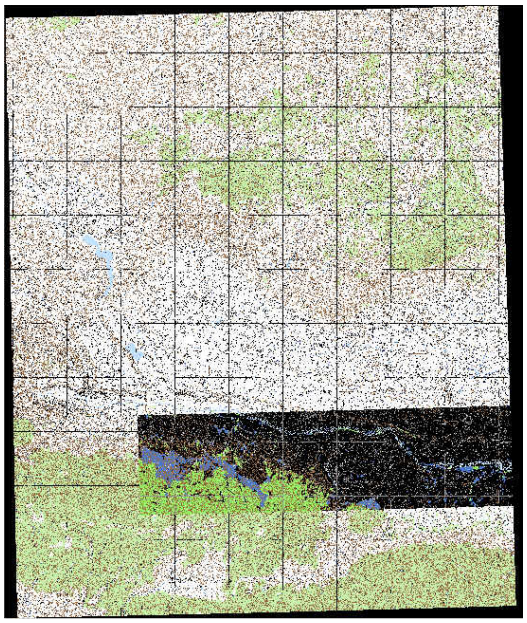


Figure 5 Distribution of 67 object points and topographic map

	X	Y
RMS	45.7023643m	20.37060649m
XY RMS	50.03666367m	
Height error	7.862 m	

Table 1 Accuracy of reference DEM

	X	Y
RMS	14.971152m	12.962885m
XY RMS	19.803328m	
Height error	7.862m	

Table2 Accuracy of reference DEM after eliminating the error

In 67 points, there are 30 points distributed in the mountainous terrain, other 37 points distributed in the hilly terrain. The accuracy is different.(Table3,4)

Plan	X	49.95104875m
	Y	16.19771m
	XY	52.51164741m
Height	Z	5.669348m

Table3 The Accuracy in Hilly Terrain

plan	X	41.94271858m
	Y	23.20965m
	XY	47.93620288m
Height	Z	9.266356122m

Table4 The Accuracy in Mountainous Terrain

Based on the sensor model and the ephemeris auxiliary data, we establish a relationship between image and ground reference systems, a rigorous image processing model. And we acquire 49 GCPS(X,Y,Z) from 1:10,000 topographic map. These points are provided in Xi'an 80 system and transformed to

WGS84 system. Use the model and these GCPs, we get this result (Table 5)

Number of GCPs	0	2	4	6	8
RMS-X (m)	165.58m	11.34m	11.89m	11.49m	12.49
RMS-Y(m)	26.12m	12.27m	10.14m	9.76m	9.80
RMS-Z(m)	156.22m	11.59m	9.62m	10.14m	9.58

Table5 DEM accuracy with different number of Gcps

4 RESULT ANALYSIS AND CONCLUSION

1)The reference Dem accuracy From SPOT image Company (IGN)is available.
2)With no GCPs , the error is big, the main factor is that the accuracy of satellite initial attitude angle is low..
3) With sparse GCPs, the DEM accuracy from SPOT5 HRS gets big improvement. Only 2-6 Gcps are need.
4) With sparse GCPs, the DEM from SPOT5 HRS Can satisfy the requirement of 1:50000 mapping.

5 REFERENCE

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