3-DIMENSIONAL GROUND COORDINATES DETERMINATION ACCURACY ANALYSIS BASED ON STEREO IMAGING ANGLE IN KOMPSAT-3A

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ABSTRACT: In this paper, we present three-dimensional ground coordinates determination accuracy in stereo images taken in single-pass stereo images and multi-pass stereo images of KOMPSAT-3A. The ground control points needed for the computed 3D ground coordinate accuracy evaluation were GPS survey results. Radiometric and Spatial correction such as de-nosing, histogram enhancement and MTFC processing was processed to improve the interpretation image point according to the ground control point in the stereoscopic image. The determination of three-dimensional coordinates using the RPC was evaluated for accuracy using the relative orientation and the absolute orientation using the Socket Set S/W.

1. INTRODUCTION

After launching in March 2015, KOMPSAT 3A performed geometric, spatial and radiometric calibration and validation during the first six months. The image data service started in January 2016 to provide users with image data collected from satellites. The KOMPSAT-3A can be taken imaging in five ways: Strip imaging, Multi-point imaging, Wide Area Along Imaging, Wide Area Arbitrarily Imaging, and Single Pass Stereo Imaging. The main requirement of satellite performance measurements of KOMPSAT-3A are MTF, SNR, and Location accuracy.
Single Pass Stereo Imaging is a method of acquiring stereo images through pitch maneuvers. This method has many advantages over the general Multi-Pass stereo imaging. First, the stereo image is acquired on the one satellite trajectory, so stereo image can be obtained easily and quickly. The second is a stereo image acquired at the same time, so the radiometric characteristics of the image are similar. Therefore, stereo images of KOMPSAT-3A can acquire terrestrial three-dimensional information quickly.
In this study, we present three-dimensional positional accuracy of KOMPSAT-3A stereo image. We propose aerial triangulation accuracy, digital elevation model accuracy, and ortho-image accuracy using the generated digital elevation model using the ground control point and the tie point observed from the stereo image.

2. TEST AREA AND DATA PROCESSING

2.1 Test Area

The KwaZulu Natal of South Africa region was selected to evaluate the three-dimensional positioning accuracy of the KOMPSAT-3A stereo image. As shown in Figure 1, the main land cover features consist of residential, arable land and coastal areas. The height range of the test area is 0 meter to 550 meters.
GCPs(Ground Control Points) should be needed for aerial triangulation, ortho-image and DEM processing. It was purchased from CompassData Inc. which located in Colorado, USA. The purchased GCPs is based on the GNSS survey. The accuracy of GCPs are 10 cm horizontal accuracy and 3 cm to 10 cm vertical accuracy.

(a) Backward image (b) Forward image

Figure 1. Stereo test dataset and land cover characteristics

Table 1. The properties of the used KOMPSAT-3 stereo data set.

Items	Forward image	Backward image
Date	2019.02.28 11:38:19	2019.02.28 11:39:48
Latitude	-29.61859997	-29.61863192
Longitude	31.1102	31.1100
roll	5.88	5.89
pitch	-29.77	30.02
yaw	6.42	0.03
Azimuth	176.453	339.415
Incidence	32.982	33.571
Elevation	57.018	56.429
Off-Nadir	30.148	30.686
Column	0.65	0.65
Row	0.76	0.77

Figure 2 shows the absolute orientation of the aerial triangulation and the distribution of a total of eight GCPs used in the generation of ortho-images.

(a) Stereo image (b) Ortho image

Figure 2. Distribution map of GCPs

2.2 Data Processing

The contrast enhancement, histogram stretching, and PAN sharpened images were generated to improve the accuracy of 3D coordinate determination using KOMPSAT-3A stereo image. The aerial triangulation consists of a relative orientation that constantly keeps a relative stereo geometric with respect to the tie point of the stereo image and an absolute orientation using the ground control points. In this study, refine RPC using GCPs was updated to use, the accuracy of

0.3 pixel (relative orientation) and 0.72 meter (absolute orientation). The refine RPC model is used affine model and 2nd polynomial model.

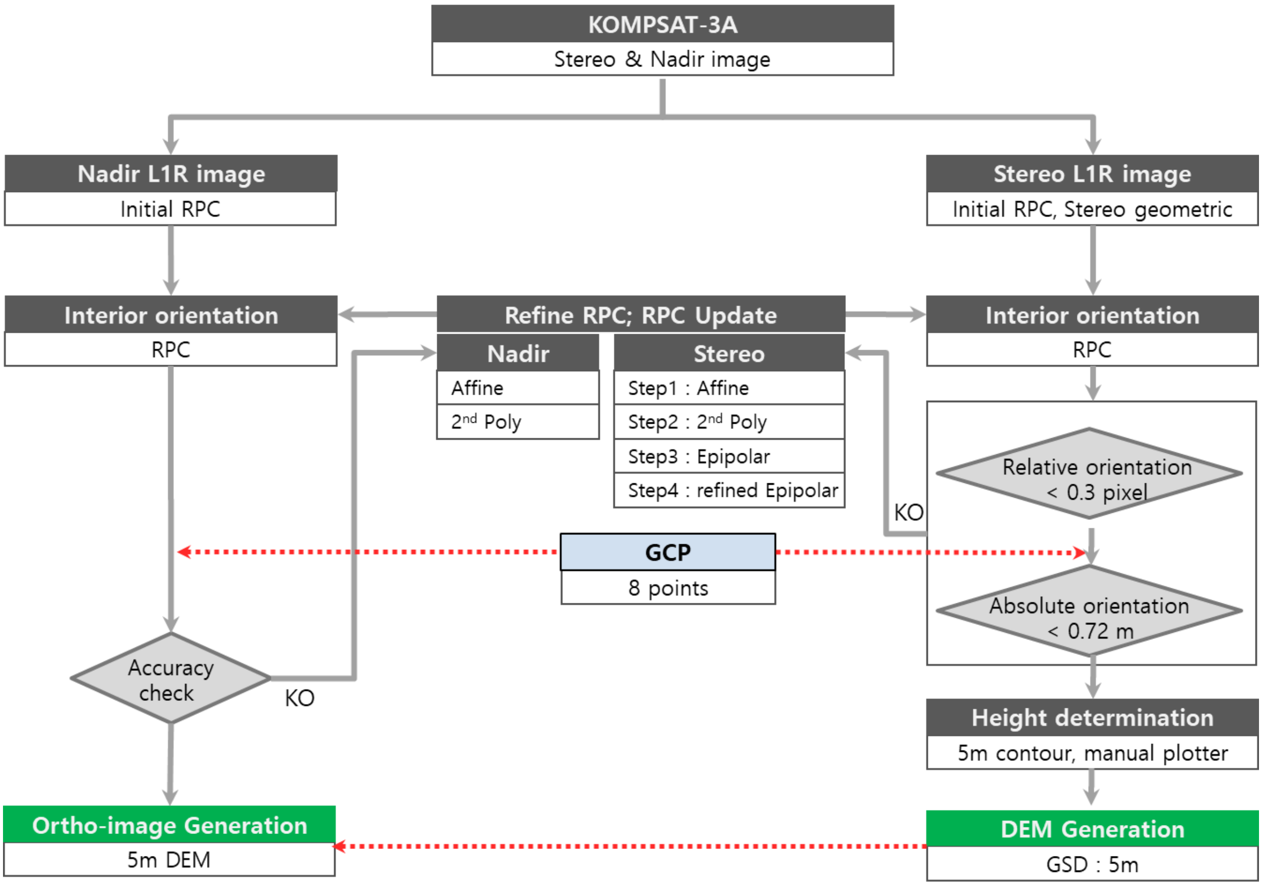

Figure 3. Work-flow

Figure 3 shows the overall working process of generating three-dimensional ground information, DEM and northo-image, from the KOMPSAT-3A stereo image.

The generation method of DEM used the extracting the contour line and the reference elevation point through visual interpretation based on the accuracy obtained from the image orientation. In geodetic surveying, the digital mapping of a topographic map using a digital graph is called a digital map plot. The digital map plotting method corresponds to the ground coordinates of feature objects in the left and right stereo images after performing relative orientation and absolute orientation. If you use the measuring mark or floating mark on the digital map plot system to track and describe the desired terrain and feature, the detailed topographical map will be drawn accordingly. The detailed process is as shown in Figure 4, and the results of the numerical mapping, TIN and DEM generation, and the accuracy test generated for each step are shown in Figure 5.

Step1: Set up the area to extract the contour and elevation
-100% overlap region of forward and backward stereo image

Step 2: Extract the contour and elevation
- 5m intervals, 100% manual drawing using digital photogrammetry system
- Extraction Layer Code: 7111 (5m contour), 7114 (25m contour), 7217 (elevation), 2111 (water area)

Step3: Generation of polylines / points for TIN creation and inspection

Step4: Generation of TIN
- Generating TIN using contours and elevation points
- Use the DTM work area of step 1 as an outer break-line and convert

Step5: TIN Quality Inspection
- Inspection of spike, well, duplicate, missing line
- Repeat Step 4 / Step 5 until there are no errors and discontinuities in the entire area.

Step6: Generation of GRID
- 5m grid spacing
- Coordinate system setting, data type (Float) setting

Step7: Accuracy Check
- Set up checkpoints to distribute
- Bicubic Interpolation applied to extract DTM Z value

Figure 4. Work-flow of DEM generation and accuracy check

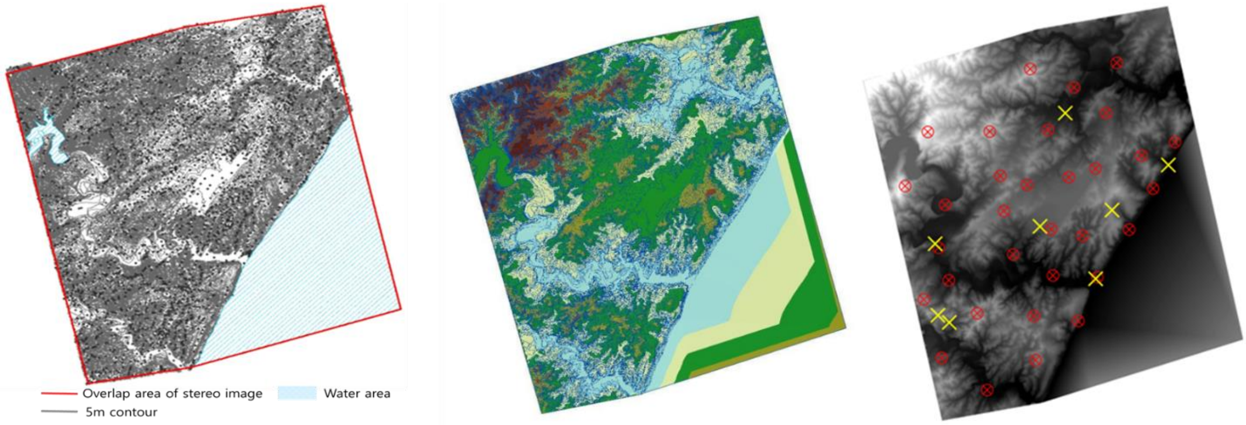

Figure 5. DEM generation step and check points

The Ortho rectification is an essential task in order to minimize the distortion caused by terrain and the distortion caused by terrain in high resolution satellite images such as KOMPSAT-3A. Satellite image used for orthodontic correction can use both Nadir image and Off-Nadir image, but in general, direct image has less geometric distortion and less square area than inclined image. It is advantageous. In this study, ortho-images were generated using Nadir image and DEM generated through this study.

3. RESULT AND DISCUSSION

The accuracy of three-dimensional coordinate determination of KOMPSAT-3A stereo image was evaluated by the accuracy according to the overall work process shown in Figure 3. In the first stage of aerial triangulation, the accuracy of relative orientation and absolute orientation is shown in Table 1.

L1R RPC		updated RPC	
Relative orientation	Absolute orientation	Relative orientation	Absolute orientation
1.023	0.279	0.227	0.158

When RPC update was not performed, it was 1.023 pixel and 0.279 meter. Since a relative orientation of 1.023 pixels produces a parallax, 0.227 pixels were secured by performing RPC update using the ground reference point. The generated DEM accuracy was evaluated by 40 reference points as shown in Fig. 5, and the accuracy of 0.218 meters was obtained. The accuracy of the ortho-image produced in this study was evaluated by arranging a total of 32 reference points as shown in Figure 8. The accuracy of the ortho-image was 0.669 meters.

4. CONCLUSION

In order to evaluate the three-dimensional position accuracy of KOMPSAT 3A stereo image, DEM, Ortho-image was fabricated and evaluated for accuracy. As a result of the accuracy evaluation, the DEM accuracy generated was 0.218 meters and the ortho-image accuracy was 0.669 meters.

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