GEO-LOCATION ERROR CORRECTION FOR SYNTHETIC APERTURE RADAR IMAGE

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1. INTRODUCTION

Spaceborne synthetic aperture radar(SAR) can provide a high resolution image in all weather conditions, but it inherently contains the errors from the ground range nonlinearity and earth rotation. Thus, SAR image has to be corrected in the process of the SAR image utilization[1],[2]. The geometric calibration parameters can be divided into absolute error and relative error terms. The absolute geometric calibration of an image can be described by two parameters: location and orientation, while the relative geometric calibration parameters describe the internal geometric fidelity of the SAR image. In this paper, a geolocation error correction method is presented for curing the relative and absolute errors which include the azimuth skew and ground range nonlinearity error, and orientation error. Using RADARSAT-1 raw data, a simulation has been conducted to evaluate the proposed geo-location algorithm, and the corrected SAR image results are compared with the GCP of the EO image.

2. GEO-LOCATION ERROR CORRECTION

The procedure of geolocation is shown in Fig. 1. The geolocation error correction method involves a relative error calibration and absolute error calibration. The first step is azimuth deskew in the relative geolocation. The second step is to project the SAR image in slant range onto ground range considering the incident angle. The last step is the image orientation correction and determination of latitude and longitude in absolute geo-location.

2.1. Azimuth Deskew

A conventional spaceborne SAR has a wide swath to cover a maximum area. There is a significant change in the rotational velocity of the earth from the near edge to the far edge of the swath. As a result, a differential shift of Doppler frequency exists in the return echo. The amount of skew depends on the difference between the actual Doppler response of each target[3].

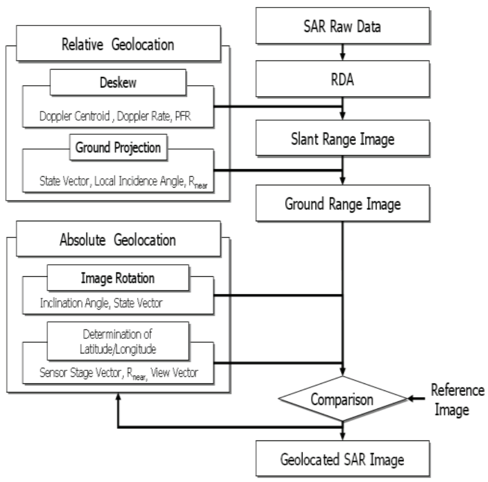


Fig.1. Procedure of Geo-location error correction

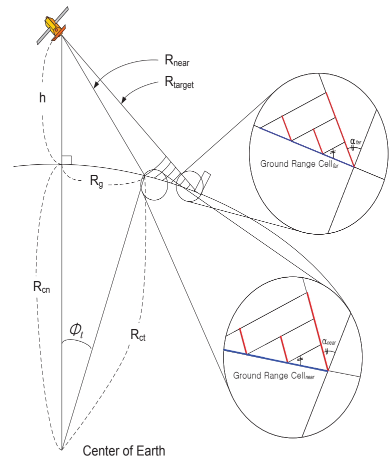


Fig. 2. Local incidence angle at near-far range

2.2. Ground projection using incidence angle

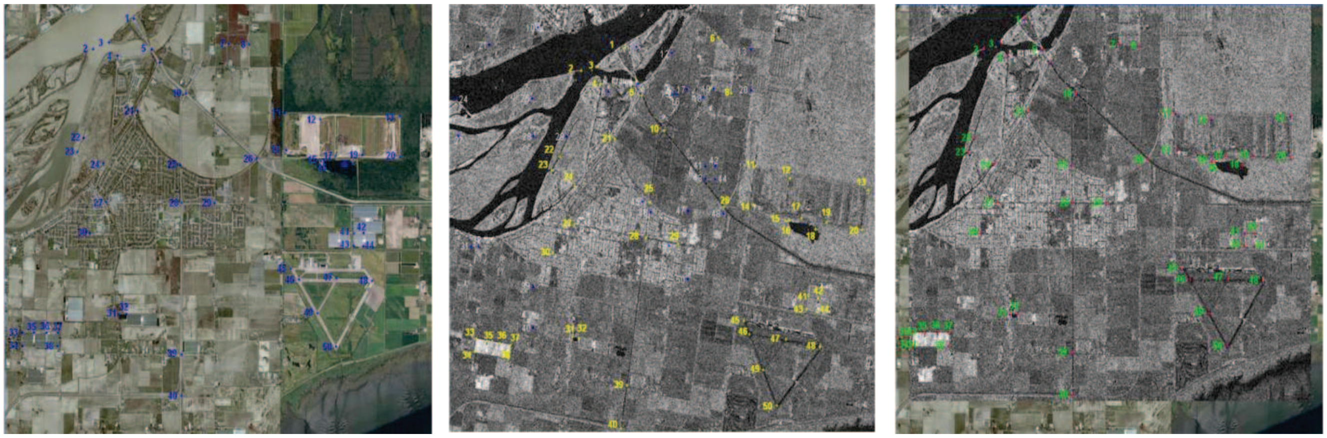
From the side-looking operation of the satellite, the SAR image formed by RDA becomes slant range image. Fig. 2. shows the range-nonlinearity errors from local incidence angle. An incidence angle can be changed depending on the region of interest from the near range to the far range and thus image scale is different between the slant range image and the ground range image. A distance error exists between original image and slant range image since this difference can cause a nonlinear scale gain depending on the ground range.

2.3. Orientation compensation

Sensor orientation is defined by three parameters: roll, pitch and yaw. Yaw is defined as the rotation around Z-axis (plumb direction). Yaw gives no direct impact on the geometry of the obtained image (no change in scale). Instead, a slightly different area from the planned one is covered in a yawed image.

3. SIMULATION AND PERFORMANCE COMPARISON

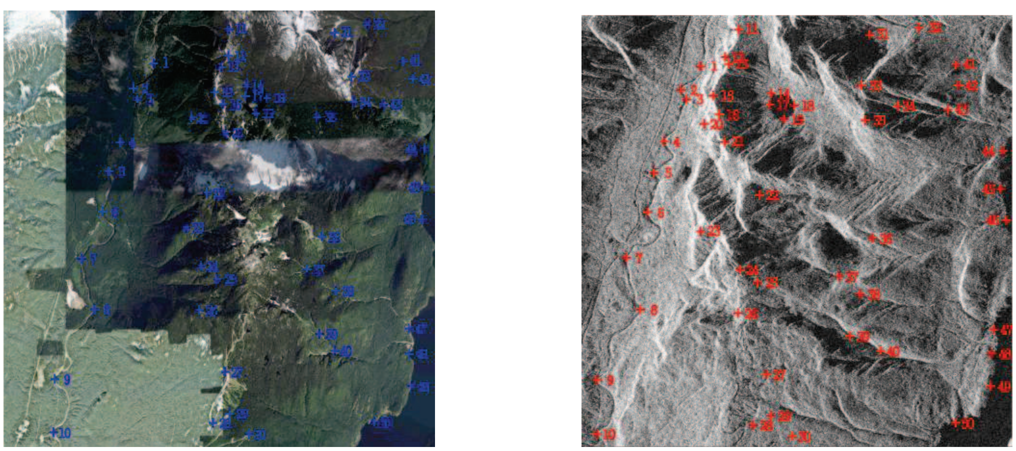
The geo-location error correction method has been simulated using RADARSAT-1 image of Vancouver. In this paper, 10m x 10m resolution is used, and Northing(azimuth) and Easting(range) errors are measured and compared with the ground control point in every direction in terms of root mean-square error (RMSE) distance [4]. The 50 reference points are designated in the EO and SAR images, and compared the same reference point to measure the distance error in the position of the East and North.



(a) EO Reference Image (b) Before Error corrected SAR Image (c) After Error corrected SAR Image

Fig. 3. Comparison of reference image and SAR image

Fig. 4 shows the comparison of the electro optical reference image and the SAR image. The values of RMSE are about 3,335m in Fig. 3 (b) and 15.2m in Fig. 3 (c). The residual error of after error corrected image, northing and easting's mean errors are about 4.7m. But values of standard deviation are 5.6m in northing and 10m in easting. This is caused by building and local height.



(a) Reference Image (b) Error Corrected SAR Image

Fig. 4. Simulation Results of mountainous area

The simulation results of mountainous area are shown in Fig. 4. The value of RMSE is about 753m in easting. Fig. 5. shows the simulation results of plain area. The value of RMSE is about 7.2m in easting. This results shows the plain area's RMSE is smaller than mountainous area, that caused by plain area's height is more flat than mountainous area.

(a) Reference Image (b) Error Corrected SAR Image

Fig. 5. Simulation Results of plain area

4. CONCLUSION AND DISCUSSION

In this paper, a geolocation error correction method is proposed. The performance of the proposed algorithm has been evaluated in terms of the RMSE distance by correcting the azimuth skew, range nonlinearity, and image orientation errors using the SAR image of the RADARSAT-1. The proposed algorithm shows good performance in correcting a geo-location error without aid of DEM or GCP data. It is suppose to be used where auxiliary data is not available like coast or the polar regions. Further evaluation is going to be performed on SAR images taken by each different mode of KOMPSAT-5.

5. ACKNOWLEDGEMENTS

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6. REFERENCES

[1] J. C. Curlander, and R. N. McDonough, *Synthetic Aperture Radar ; system and signal processing*, Wiley-interscience, 1991.

[2] I. G.Cumming, and F. H. Wong, *Digital Processing of Synthetic Aperture Radar Data*, Artech House, 2002

[3] J. C. Curlander, *Utilization of Spaceborne SAR Data for Mapping*, IEEE Transactions on Geoscience and Remote Sensing, Vol. GE-22, No. 2, pp. 106-112, 1984

[4] J. Gao, *Digital analysis of remotely sensed imagery*, Mc Grow Hill, 2009.