THE PEFORMANCE ANALYSIS OF ORTHORECTIFIED IMAGE GENERATION USING RIGOROUS SENSOR MODEL

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ABSTRACT: Orthorectified image generation traditionally use height and GCPs(Ground Control Points) to correct the height distortion caused by the terrain height within every pixels of input images. The traditional method spends a lot of time to calculate the amount of the equations to establish the sensor model by using GCPs and for the image processing. The ground station of commercial satellites widely distribute the orthorectified images as the geometric corrected level. We have to provide the more accurate image. For this, we suggest the fast orthorectified image generation algorithm using grids. Our algorithm comprise 3 steps : (1) we need to establish the rigorous sensor model using precise orbit data and precise attitude data. (2) the input image is divided into grids by equivalent space considering DEM's resolution. and (3) Ortho-rectified images are generated by using grids with bilinear interpolation. Our proposed algorithm by using grids is more effective than algorithm corrected every pixels of input images. As the result, we successfully acquired the orthorectified image within 10 minutes.

1. INTRODUCTION

So many commercial satellites offer the orthorectified images to user timely. In case of SPOT-5, they broadcast the ortho-images within 4 hours(S. Bailarin and et al. 2005). Therefore, we need to develop the technique for orthoimage generation using DEM data without GCPs within specific processing time. To quickly acquire the orthocorected image, we used the girds having an equal interval. To validate our suggested algorithm, the geolocation errors of the geocorrected image are compared with the orthorectifed image. At first, the geocorrected image was generated by using the camera model and changing grids size and the orthorectified image is also generated by the same camera model and changing grids size. Our experiments used the satellite image with 1m and 4 m spatial resolutions and 3 arc seconds SRTM DEM data. This DEM data have a resolution of 90m at the equator(CGIAR-SCI, 2008). Our method makes it possible to quickly correct height distortion caused by the difference of earth surface. At first, the input images are divided into grids by equal intervals. The number of girds are decided by the size of input images. In case of the orthorectified, grid's pixel location is converted into latitude and longitude calculated by the sensor model using ephemeris data, and then get the elevation values from DEM data correspond to the latitude and longitude calculated by model using satellite ephemeris data and finally calculate the orthocorrected locations at the image coordinates. But in case of the geocorrected, we don't use the DEM data. For these correction, the grid's locations at the input image's image coordinates are replaced by the corrected images using bilinear interpolation.

2. METHODOLOGY

In this paper, we are focused on validating the improvement of the geolocation accuracy and then we check the difference of the errors between the geocorrected and orthorectified image. Our suggested algorithm is to generate the result image depending on grids calculated by whether using DEM or not. Therefore, we explain our algorithm as 2 steps; the rigorous model was established by using PAD and POD and the girds were generated by input images depending on whether using DEM or not.

2.1 Rigorous Sensor model

The sensor model is the numerical relationship between image coordinates and ground coordinates using ephemeris data which are the position and velocity vector and attitude data provided from on-board. Our sensor model is to accurately correct the systematic errors without GCPs. That makes it possible to quickly correct the distortion caused by height. Our rigorous model means the orbital sensor model, as below (3),

$$\begin{pmatrix} x \\ y \\ -f \end{pmatrix} = R_{rpy} R_{\vec{P},\vec{V}} \begin{pmatrix} G_X - S_X \\ G_Y - S_Y \\ G_Z - S_Z \end{pmatrix} \tag{1}$$

where (Sx, Sy, Sz) is the coordinates of satellite position, (Gx, Gy, Gz) the ground coordinates and (x, y, -f) the image coordinates. R_{rpy} is the rotation matrix determined by roll, pitch and yaw, R_{PV} is the rotation matrix determined by position and velocity vectors. These vectors of the position and velocity assumed the nominal vector due to the eccentricity of the orbit. Our model used the attitude data, such as roll, pitch and yaw angles, offered by ephemeris data. But our sensor model internally includes errors because of the position and attitude shifts of satellite on the orbit. Therefore, we need to analyze the geometric errors.

2.2 Orthorectification

Our ground station usually provides the acquired image within the required time to user. Our method is to fast generate the orthocorrection of the satellite acquired images only used DEM data not GCPs. That also make it possible to correct ground-relief distortions caused by the relief of a ground surface without an excessively large amount of calculation.

The processing of orthorectified image is 3 steps; (1) the input image projected on map projection, (2) the projected image of input divide to grids using DEM and finally (3) generate the orthocorrected image using grids.

For this, the input image is projected on map projection to calculate the projected image and then, the projected image of input is divided into blocks by lattices of equal intervals. With respect to each of these blocks, latitude and longitude of the corresponding pixel location (column, row) of satellite image calculate the pixel location of the orthocorrected image by using our sensor model. At that time, we can have a choice to use DEM or not depending on the orthocorected or geocorrected image. However, the grid size must have the decision based on the resolution of DEM. We traced the height information according to latitude and longitude and we update pixel location using height. Finally, pixels of input images are replaced on calculated pixels of output images.

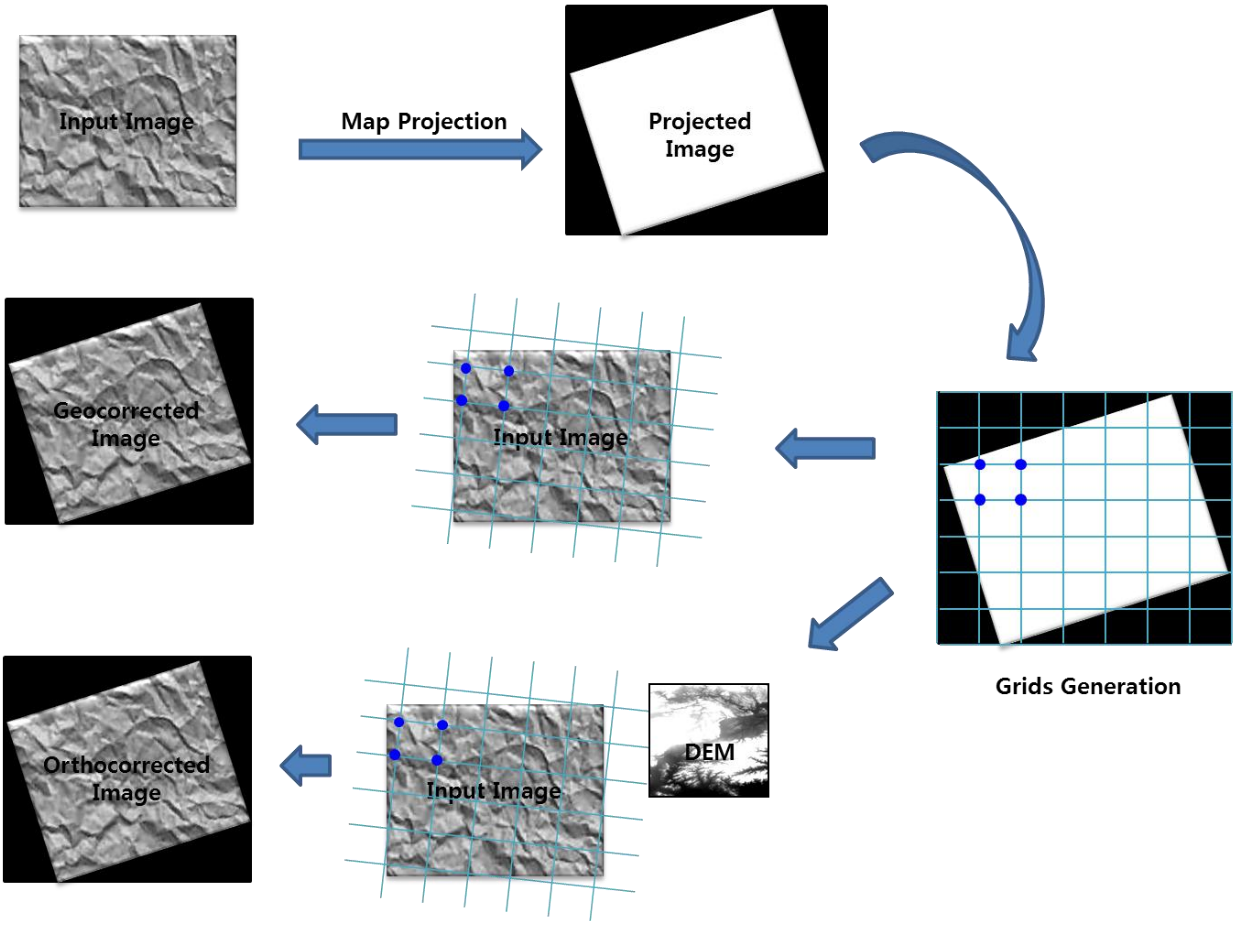

Figure 1. The Procedure of the Corrected Image Generation depending on DEM

3. RESULTS

Our experiment is to validate the improvement of the geoaccuracy of the difference between the geocorrected and the orthocorrected image. At first, the geocorrected image was generated by changing girds size, such as the 100m, 200m, 300m, and 400m and the orthocorrected image also generated by the same grids size. As the results, the orthocorrection is to improve the geo-accuracy and we must choose the most appropriate grid size to more effective generate orthoimage by considering the total processing time within about 10 minutes. We used the data as Table 1.

Table 1. Experiment Data information

Input Data	Satellite image (Pan, MS(Red, Green, Blue, NIR))
GSD	4m
Input Image Size	15000x15500, 3750x3875
Output Image Size	24216x21912, 6054x5478
Tilt Angle[Deg]	28.9
DEM	SRTM
DEM resolution	3”
GCP	20

For checking the accuracy, we used the twenty GCPs for the visual inspection. The results of the gecorrected image are shown as Table2 and The results of the orthocorrected image shown as Table3.

Table 2. The Accuracy of the Geocorrected Image depending on Grids Size

Grid Size	$RMSE_X$ [m]	$RMSE_Y$ [m]	$RMSE_{Total}$[m]	CE90 [m]	CE95 [m]
100	127.0977	50.17529	136.6432	207.3561	236.502135
200	127.3424	50.21325	136.8849	207.7228	236.920307
300	127.4519	50.20292	136.9829	207.8716	237.090059
400	127.4519	50.21693	136.9881	207.8794	237.098949

Table 3. The Accuracy of the Orthocorrected Image depending on Grids Size

Grid Size	$RMSE_X$ [m]	$RMSE_Y$ [m]	$RMSE_{Total}$[m]	CE90 [m]	CE95 [m]
100	13.98272	74.0108	75.32009	114.2982	130.364008
200	13.99834	75.11534	76.40856	115.95	132.247941
300	17.99675	74.45516	76.5993	116.2394	132.578074
400	20.8466	74.37994	77.24607	117.2209	133.697502

As the results, the orthocorrected image applied by our suggested algorithm is the more accurate than the geocorrected image. The difference between the minimum and maximum errors of the geocorrected image generated by changing the size of grids, is about 0.34482m, but in case of the orthocorrected image about 1.925985m. Therefore, we validate the improvement of the orthocorrected accuracy through our experiment.

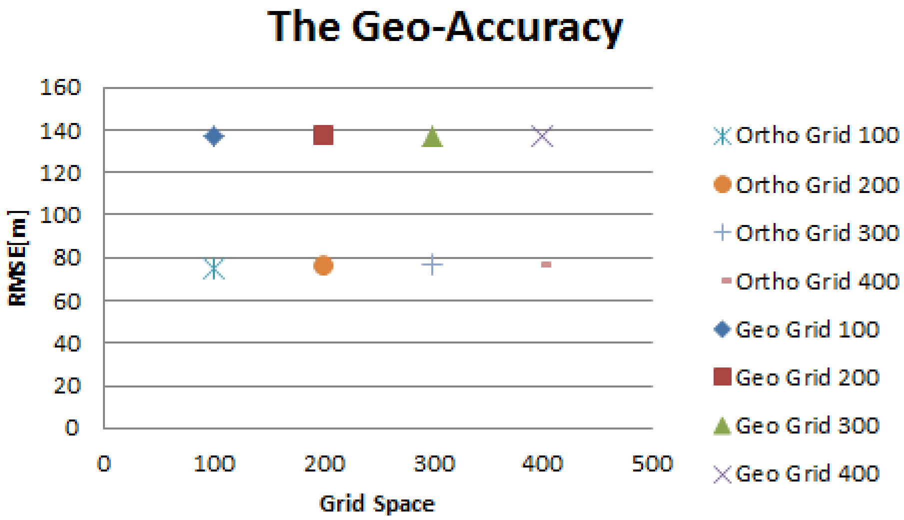

Figure 2 The Accuracy of Orthocorrection and Geocorrection depending on Grids Size

The total processing time of each experiment is about 3minutes, and our processing time is satisfied with the required processing time. By considering the processing time and the geo-accuracy, we can select the most appropriate grid size and then finally decide the 200m grid. Fig3 is shown as the error vectors of the orthocorrected image using 200m grid. These vectors show the errors of the orientation and magnitude of each point.

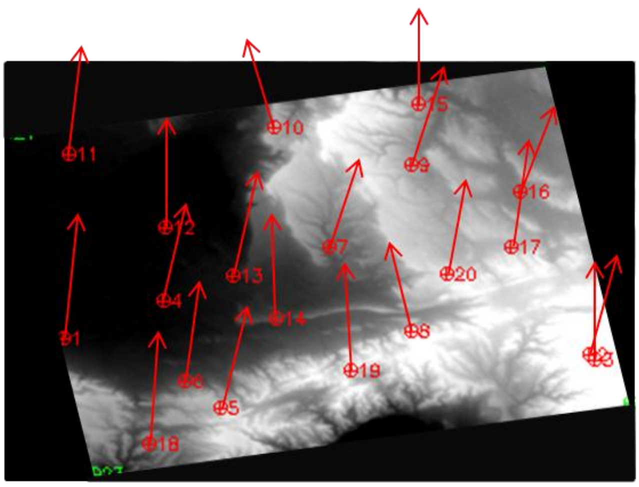

Figure 3 Exaggerated Error Vectors of Orthocorreded Image

4. CONCLUSION

For analyzing the performance of our suggested algorithm, we validate the improvement of the geoaccuray to compare the geocorrected image and orthocorrected image. As the results, the geocorrected image including the errors of 207.7228m(CE90), but our orthocorrected method dramatically improve the accuracy of the geolocation up to 115.85m (CE90). We finally acquired the more accurate and quickly image applied by our suggested orthocorrection algorithm.

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