[GEOMETRIC CORRECTION, ORTHORECTIFICATION AND MOSAICKING]

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March 12, 2013

Ref: DIP/D3

Janet Finlay
GIS-GM Program Professor
Niagara College
135 Taylor Road
Niagara-On-The-Lake, ON
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Dear Janet

RE: GISC9216 Geometric Correction, Ortho-rectification and Mosaicking

Please accept this letter as my formal submission of AssignmentD3: Geometric Correction, Orthorectification and Mosaicking GISC9305- Digital Image Processing.

This Assignment is aimed at using Erdas Imagine to rectify high resolution images (airborne or space borne) to able to correct or remove terrain distortion to produce a reliable image in support of GIS.

Sir, it has been an interesting and educative exercise, that has expose me to a better way of rectifying images using (polynomial and camera method).

Should you have any regarding the enclosed documents, please contact me through my Email (kolamibeabuchi@gmail.com).

Thank you for your time and attention. I look forward to your comment and suggestions.

Kindest Regards

Ibeabuchi Nkemakolam.HND Surv& Geo

GISC-GM Certificate Candidate

Enclosure: Hard copy report
Abstract

A significant problem in satellite imagery is geometric distortion. Accurate remote sensing and high resolution satellite images have made it necessary to revise the geometric correction techniques used for ortho-rectification. There are some sources of geometric distortion of images data than radiometric distortion and their effects are more severe. These can be related to a number of factors, including rotation of the earth during image acquisition, the finite scan rate of some of the sensors, the wide field of view of some of the sensors, the curvature of the earth, on-ideal behavior of the sensors, variation in the platform altitude and the velocity and the panoramic effects of related to the imaging geometry.

Therefore Conventional methods of photogrammetric modeling of remotely sensed images are insufficient for mapping purposes and need to be substituted with more rigorous approach to get a true ortho-photo.

Hence geometric correction is undertaken to overcome geometric distortions resulting from factors stated above during the acquisition of digital or scanned image. Rectification process is achieved by establishing the relationship between the image coordinate system and the geographic coordinate system.
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Introduction

Preprocessing of satellite images prior to image classification and change detection is essential. Preprocessing commonly comprises a series of sequential operations, including atmospheric correction or normalization, image registration, geometric correction, and ortho-rectification.

Geometric correction is necessary to preprocess remotely sensed data and remove geometric distortion so that individual picture elements (pixels) are in their proper planimetric (x, y) map locations. This allows remote sensing–derived information to be related to other thematic information in GIS. Geometrically corrected imagery can be used to extract accurate distance, polygon area, and direction (bearing) information.

Pictorial explanation of the stages of rectification of imagery (airborne or space borne).
Objectives

Overall Objective
The objective of this project is using geometric correction, to remove terrain distortions in imagery (airborne or space borne) to produce reliable image data in support of GIS application. There are two major task involved in this project to achieve our objective (geometric correction) these are:

   a.) First task : Polynomial correction and Mosaicking
   b.) Second task : Ortho-rectification and Mosaicking

Study Area

![Study Area Imagery](image)

*Figure 1: Study Area Imagery*
Methodology

Data provided

The following data (Photo Imagery) were provided for geometric correction;
- 3 aerial photos: Photo_1.tif; Photo_2.tif; Photo_3.tif
- Digital elevation model: DEM.img
- An existing geo-referenced image: subset_existing.img
- Vector files (shapefiles): Roads and Buildings.

A broad sequential process was used to effect geometric correction of the photo these are;

- Polynomial Correction and Mosaicking
- Ortho-rectification and Mosaicking

Polynomial Correction and Mosaicking

A 1st order polynomial function was used to fit the image coordinates (input) to reference coordinates (GCPs) for photo1 and photo2; 10 GCPs were chosen and 3rd order polynomial was adopted for photo3. The nearest neighbor technique was adopted. Resampling allocates spectral value to the pixel; these processes the newly created “Empty “Image poly1, 2 and 3 which may have the same, small or bigger size. The resample images (poly1, 2 and 3) were further processed by sub-setting the newly created images.

Sub-Setting: It means to breaking out portion of a large file into one or more smaller files. Often, image files contain areas much larger than a particular study of interest (AOI). Sub-setting is necessary because we are working with a large image. This process speed up processing due to the smaller amount of data to process.

Mosaicking

The three overlapping images is then mosaic joined together to form a uniform image of the area being analyzed.

Ortho-rectification and Mosaicking

Ortho-rectification it an operation carried out on an image to correct distorted or degraded image data to create a more fruitful representation of original image.

Mosaicking the 3 results of the ortho-rectification to form a uniform or one image of the area being analyzed.
SECTION ONE

PREDICTION PROCESS / EFFECTS

After entering 4 GCPs or more for your polynomial geometric correction, is the prediction process giving you a good localization of the GCP you enter? Explain why.

1st order polynomial was adopted for this first phase of this geometric correction, after entering 4 GCPs the software prediction process wasn’t giving me good and accurate localization of the GCPs but it was very close. It was caused by the mathematical equation of polynomial transformation which is the relationship between pixel locations (row, column) and rectified pixel location. It can also be said to be as a result of the Image matching approach by the software; it is based on the reflectance values.

Mathematical equation:

\[
X = A_1X' + B_1Y' + C_1X'Y' + D_1
\]
\[
Y = A_2X' + B_2Y' + C_2Y' = D_2
\]

This point is determined based on the current transformation derived from existing GCPs.

Figure 2: Image showing GCPs localization prediction and difference in position

The image above shows the bad prediction of localization of the GCPs entered during 1st polynomial correction. It should be noted that there was wrong prediction of localization of GCPs in 3rd Polynomial of photo 2 and photo 3.
Meaning of RMS ERROR

For each photo that will be geometrically corrected, take note of the total error of the “Control Point Error”. Explain what is this error?

The “Control Point Errors (RMS)” It is the distance between the input (source) location of a GCP and the retransformed location for the same GCP. In other words, it is the difference between the desired output coordinate for a GCP and the actual output coordinate for the same point, when the point is transformed with the geometric transformation.

RMS error is calculator with a distance equation:

\[
\text{RMS error} = \sqrt{(x_r - x_i)^2 + (y_r - y_i)^2}
\]

Where:

- \(x_i\) and \(y_i\) are the input source coordinates
- \(x_r\) and \(y_r\) are the retransformed coordinates

RMS error is expressed as a distance in the source coordinate system. If data file coordinates are the source coordinates, and then the RMS error is a distance in pixel widths. For example, an RMS error of 2 means that the reference pixel is 2 pixels away from the retransformed pixel. The RMS of each points helps to evaluate the GCPs.

Figure 3: Control Point Error (RMS) Table
Order of polynomial Transformation

<table>
<thead>
<tr>
<th>GCP</th>
<th>1\textsuperscript{st}, RMS Error</th>
<th>2\textsuperscript{nd}, RMS Error</th>
<th>3\textsuperscript{rd}, RMS Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.012</td>
<td>0.021</td>
<td>0.024</td>
</tr>
<tr>
<td>2</td>
<td>0.005</td>
<td>0.005</td>
<td>0.013</td>
</tr>
<tr>
<td>3</td>
<td>0.021</td>
<td>0.022</td>
<td>0.124</td>
</tr>
<tr>
<td>4</td>
<td>0.008</td>
<td>0.034</td>
<td>0.212</td>
</tr>
<tr>
<td>5</td>
<td>0.008</td>
<td>0.031</td>
<td>0.027</td>
</tr>
<tr>
<td>6</td>
<td>0.006</td>
<td>0.028</td>
<td>0.028</td>
</tr>
<tr>
<td>7</td>
<td>0.003</td>
<td>0.012</td>
<td>0.015</td>
</tr>
<tr>
<td>8</td>
<td>0.006</td>
<td>0.027</td>
<td>0.121</td>
</tr>
<tr>
<td>9</td>
<td>0.006</td>
<td>0.025</td>
<td>0.124</td>
</tr>
<tr>
<td>10</td>
<td>0.013</td>
<td>0.022</td>
<td>0.023</td>
</tr>
</tbody>
</table>

Average control point Error of 0.255

**CHANGE IN PIXEL VALUE**

During the creation of the resampled image, take note of the default pixel size of each output corrected photo. Is the pixel size of all the 3 corrected photos the same? Explain why. (Keep in mind that the photos have been acquired by the same sensor under the same conditions and at the same time)

The pixel sizes of all the 3 corrected photos where not the same after resampling when compared with the original pixel size of the default photos. The default pixel sizes of the photos was (Pixel size X: 0.00250, Pixel size Y: 0.00250) before resampling but the sizes doubled by two after resampling (Pixel size x: 0.4987726152, Pixel size Y: 0.4987726152), approximately. The reason for a new pixel sizes after resampling (Using nearest neighbor) is that the new pixel receives the value of the pixel centroid that is closest to it after being shifted. The two tables below show the changes that have taken place in the pixel value before and after resampling process.
Figure 4: Pixel sizes before resampling

Figure 5: New pixel size after resampling
RESULT OF POLYNOMIAL MOSAIC

Check the quality of the mosaic (expected mosaic result is in figure 1 below). Is there any geometric problem in the 3 photos mosaic (check the overlap areas)? Is the overlay of the vector files over the mosaic image working properly (check roads, bridges and buildings)? Is there any shift between the image and the vector file? If yes, what is causing this shift?

The overlay of the vector files over the mosaic image worked to some extent but not properly because some features where not properly aligned after mosaicking the Poly1, Poly2 and Poly3 images together. There was a shift between the image and the vector files; this shift was mainly caused due by the Control Points error (RMS). The RMS error is the distance between the input (source) location of a GCP and the retransformed location for the same GCP. In other words, it is the difference between the desired output coordinate for a GCP and the actual output coordinate for the same point, when the point is transformed with the geometric transformation. The images show areas in there where shifts.

Figure 6: Images showing overlapping road

Figure 6: Image showing overlapping of roads
SECTION TWO

PREDICTION PROCESS / EFFECTS
After entering 4 GCPs or more for your ortho rectification, is the prediction process giving you a good localization of the GCP you enter? Explain why.

In the ortho-rectification (camera) 3rd order method was adopted for the correction in the 3 photos provided. After entering the four GCPs, the prediction of first few point where close but not precise. The prediction became a little way off target with more input of more GCPs by the Erdas software.
MEANING OF RMS ERROR EFFECT

For each photo that will be geometrically corrected, take note of the total error of the “Control Point Error”. Explain what is this error?

The “Control Point Errors (RMS)” It is the distance between the input (source) location of a GCP and the retransformed location for the same GCP. In other words, it is the difference between the desired output coordinate for a GCP and the actual output coordinate for the same point, when the point is transformed with the geometric transformation.

RMS error is expressed as a distance in the source coordinate system. If data file coordinates are the source coordinates, then the RMS error is a distance in pixel widths. For example, an RMS error of 2 means that the reference pixel is 2 pixels away from the retransformed pixel. The RMS of each points helps to evaluate the GCPs. After inputting four GCPs these list of RMS errors were generated in the tables below;

![RMS errors list table]

<table>
<thead>
<tr>
<th>GCPS</th>
<th>1&lt;sup&gt;st&lt;/sup&gt; RMS Error</th>
<th>2&lt;sup&gt;nd&lt;/sup&gt; RMS Error</th>
<th>3&lt;sup&gt;r&lt;/sup&gt; RMS Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.010</td>
<td>0.012</td>
<td>0.022</td>
</tr>
<tr>
<td>2</td>
<td>0.004</td>
<td>0.020</td>
<td>0.013</td>
</tr>
<tr>
<td>3</td>
<td>0.004</td>
<td>0.010</td>
<td>0.022</td>
</tr>
<tr>
<td>4</td>
<td>0.002</td>
<td>0.023</td>
<td>0.010</td>
</tr>
</tbody>
</table>

Figure 7: RMS errors list table
CHANGE IN PIXEL VALUE

During the creation of the resampled image, take note of the default pixel size of each output orthophotos. Is the pixel size of all the 3 ortho-rectified photos the same? Explain why.

The pixel sizes of all the 3 corrected photos where not the same after resampling when compared with the original pixel size of the default photos. The default pixel sizes of the photos was (Pixel size X: 0.00250, Pixel size Y: 0.00250) before resampling but the sizes doubled by two after resampling (Pixel size x: 0.4987726152, Pixel size Y: 0.4987726152), approximately (Pixel size X: 0.05, Pixel Size Y: 0.05). The reason for a new pixel sizes after resampling (Using nearest neighbor) is that the new pixel size receives the value of the pixel centroid that is closest to it after being shifted.

![Figure 8: pixel value of resample image](image)
RESULT OF CAMERA MOSAIC
Check the quality of the orthomosaic. Overlay the vector files on the orthomosaic and check the overlay quality (buildings and roads). Is the shift between the vector files and the image less or more significant than in the first task. Compare the orthomosaic to the mosaic created in the first task.

The output overlay quality of the ortho-mosaic (camera) image after overlaying the vector files on the ortho-mosaic was full of inconsistencies. Some feature like roads and bridge were out of position when compared with the result of the polynomial mosaic exercise. The bridge was distorted and out of position (shift); the shift was more significant than the first task. The roads in the orthomosaic were better positioned (overlaid) when compare with the result of the polynomial mosaic. The results were vice versa for the both images; please refer to the images in figure 7, 8 (Polynomial mosaic and camera mosaic) below.

Figure 7: comparison image comparing results of camera and polynomial
Conclusion
The goal of this lab/assignment was achieved by creating a registered image. It was determined that the quality of the image has a major effect on the ability to provide adequate registration. The collection of GCPs ground control points may be further improved using a differentially corrected or higher quality GPS unit or other high-order surveying techniques.

(a.) The bad location and bad distribution of the selected GCPs lead to increase in the average RMS error value of corrected image.

(b.) The effect of bad location of selected GCPs is more severe than that of bad distribution of selected GCPs on the correction accuracy.

(c.) To obtain high accuracy result in geometric correction of remotely sensed satellite images, the location and distribution of selected GCPs should be taken into consideration as mentioned before.

References
Remote Sensing and Interpretation by LILLESAND/KIEFER/CHIPMAN.SIXTH EDITION

Google search Engine

ERDAS Field Guide 2010 Edition

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