PHOTOGRAMMETRY THEORY

SOFTCOPY PHOTOGRAMMETRY

CENTRE OF GEOGRAPHIC SCIENCES, NSCC
REMOTE SENSING
KATIE CHUTE - STUDENT- FEBRUARY 2017

Centre of Geographic Sciences
COGS | nscc

The meaning behind this Theory poster is to show/tell that we have an understanding of the photogrammetric concepts that have been applied throughout this Softcopy Photogrammetry course. This theory poster will also go on to show/tell you how these concepts are applied to the processing of aerial photography.

The concepts that were applied throughout this course are as follows: Interior Orientation, exterior orientation, collinearity (condition & equations), space intersection (ground & tie points), space resectioning (single frame), aerial triangulation, flightline planning, exterior orientation estimation, self-calibrating bundle adjustment, Coplanarity condition, Epipolar alignment, cross-correlation & least squares matching, DEM production, and finally Orthorectification.

For this theory poster the main concepts that we'll take a look at are the following: Interior orientation, exterior orientation, collinearity condition, aerial triangulation, flightline planning Coplanarity condition & Epipolar alignment, image matching, Digital Elevation Model (DEM) production, and finally Orthorectification process.

Interior Orientation

"Interior orientation defines the internal geometry of a camera or sensor as it existed at the time of data capture. The variables associated with image space are defined during the process of interior orientation. Interior orientation is primarily used to transform the image pixel coordinate system or other image coordinate measurement system to the image space coordinate system."(Hexagon found)

There are five different components to Interior Orientation those five components are as follows: Principal Point and Focal Length, Fiducial Marks, and Lens Distortion.
The principal point is defined mathematically by the intersection of perpendicular lines that is going through the perspective middle of the image. The focal length is the length from the principal point to the perspective center of the image. Fiducial Marks are measured right on the image and are then compared to the calibrated coordinates for each of the fiducial marks. Then the final component of interior orientation is lens distortion. Lens distortion worsens the positional accuracy of the image points that are located on the image plane.

The way that interior orientation is important to photogrammetry in the way that if you do not have interior orientation then your bundle block file will not line up properly.

Exterior Orientation

Exterior orientation defines the position and angular orientation of the camera that captured an image. The variables defining the position and orientation of an image are referred to as the elements of exterior orientation. The elements of exterior orientation define the characteristics associated with an image at the time of exposure or capture. The positional elements of exterior orientation include Xo, Yo, and Zo. They define the position of the perspective center (O) with respect to the ground space coordinate system (X, Y, and Z). Zo is commonly referred to as the height of the camera above sea level, which is commonly defined by a datum.

The angular or rotational elements of exterior orientation describe the relationship between the ground space coordinate system (X, Y, and Z) and the image space coordinate system (x, y, and z). Three rotation angles are commonly used to define angular orientation. They are Omega (w), Phi (j), and Kappa (k). The "Elements of Exterior Orientation" figure below illustrates the elements of exterior orientation, and the "Omega, Phi, and Kappa" figure below illustrates the individual angles (w, j, and k) of exterior orientation.

The way that the exterior orientation is important for running your bundle block file, in the way that your images will not line up properly and they will not have any rotation on them if they need it.

Collinearity Condition, Space Intersection, Ground Control and Tie Points

The coplanarity condition is used to calculate relative orientation. It uses an iterative least squares adjustment to estimate five parameters (By, Bz, Omega [w], Phi [j], and Kappa [k]). The parameters explain the difference in position and rotation between the two images making up the stereopair.

A technique used to determine the ground coordinates X, Y, and Z of points that appear in the overlapping areas of two images, based on the collinearity condition.

(GCP) A specific pixel in image data for which the output map coordinates (or other output coordinates) are known. GCPs are used for computing a transformation matrix, for use in rectifying an image.

A point whose ground coordinates are not known, but can be recognized visually in the overlap or sidelap area between two images.

Aerial Triangulation

Aerial triangulation is used for estimating the exterior orientation parameters associated with each image in the block and for determining the X, Y, and Z coordinates of the tie points. A bundle block adjustment is being used to perform aerial triangulation. Additionally, the interior orientation parameters associated with a camera (or cameras) can be recovered using an extension to the bundle block adjustment referred to as the self-calibrating bundle adjustment.

Statistical weights can be assigned to the input observations including image coordinates, GCPs, exterior orientation, and interior orientation. The use of statistical weights assists in minimizing and distributing data error throughout the block of imagery, thereby ensuring highly accurate results.

The Aerial Triangulation dialog is broken into the following tabs: General, Point, Interior, Exterior, and Advanced Options.

The way that aerial triangulation is important to photogrammetry is it you do not put enough tie points, control points and check points then your images will not aline properly. So, this portion of the process of photogrammetry is pretty important compared to the other processing operations.

Flight Line Planning

The flightline planning will be a successful executed project, but it requires thorough planning. In order for the project to be successful, the following steps need to be completed. First thing is to select the products that need to be prepared, what are their scales, accuracies aerial photo prints, photo indexes, photomaps, digital maps, digital elevation models, and topographic maps just to name a few. Once the product selection has been completed, the planning of aerial photography needs to be completed. The planning of ground control needs to be completed before flying. Then selecting instruments and procedures necessary to achieve the desired results needs to be thorough thought about before the flying of aerial photography can be completed. Then the estimating costs and delivery schedules need to be gone over with the client before any aerial photography can be flown. The acquisition of quality images will determine if the photogrammetric project is a success or not. There are a few major things that you need to keep in mind when completing the collection of aerial photography, one of those things is the weather and ground condition for the area that you are looking at collecting aerial photography of. the period for collecting photography can be limited at times. The mission should be carefully planned and executed according to the flight plan that has been laid out. Another major thing that you needs to be kept in mind and that has to re-fly areas that can become expensive and can cause long delays for the project. A flight map and specifications of where the photos should be taken should be on hand and everyone should have a copy of this map.
Flight line planning is important to the photogrammetry process in the way that if it is not done then there will be no images to run the aerial triangulation process on. So, you need to complete the flight line planning process in order to fly and collect the images in order to complete the above process and also the process' beloew.

Image Matching

Image matching refers to the automatic identification and measurement of corresponding image points that are located on the overlapping area of multiple images. The various image matching methods can be divided into three categories including the following: Area based matching, feature based matching, and relation based matching.
Image matching is important to the photogrammetry process in the way that if you do not match the areas with one another in several images then you could have some images that look off. For example you need to match the bridge in all of the images with each other, because if you don't do this then it could look like there are two bridges when there should only be one.

Digital Elevation Model Production

Digital Elevation Model (DEM) production can be done by using the following tool and process' that can be found within the Leica Photogrammetry Suite (Erdas Photogrammetry). The tool that can be used in the creation of a DEM is the Enhanced Automatic Terrain Extraction (eATE) tool with the following steps this tool can be completed. The first is to extraction of a Digital Elevation Model (DEM) from the stereo pairs that had been created in a previous bundle block project. *"Erdas Photogrammetry has a module Enhanced Automated Terrain Extraction (eATE) dedicated to the generation of Digital Elevation Models (DEMs) from stereo pairs of aerial photographs. Before the extraction can take place, the photographs must be aligned and georeferenced via a bundle block adjustment (e.g. using control points via GPS).*
The eATE module processes any overlapping photographs (e.g. those with 50% or more overlap) to identify locations in common (similar to automatic tie-points but in larger quantity). These "mass points" can then be output directly (3D Shapefile) or used immediately to generate a raster DEM or TIN (allows detailed editing)." (Found on page 2 of 5 in the guide3_dem production PDF; First paragraph under the heading Enhanced Automated Terrain Extraction).
"Regardless of the output format of the DEM, the DTM Extraction tool (under Process / DTM Extraction / eATE) in Erdas Photogrammetry is used to generate the mass points necessary to define the terrain throughout the region.
Begin by selecting the Output Type for the DEM (e.g. DEM or 3D Shapefile). Next, select the Output Form to be Single Mosaic in order to create a single DEM file (rather than one per pair of overlapping photographs) and provide a path & filename for the file.
Choose an output cell size (or point spacing for mass points) for the DEM based on the overall scale and requirements for the DEM (e.g. 10m to 20m is reasonable for many ortho-products).
This routine relies on an accurate Z Search Range (minimum / maximum of terrain throughout the area). While the initial estimated values may be suitable, you may wish to adjust the DEM accuracy value to change the search range to more accurately match your scene (e.g. ~0 to 120 m for Bridgewater)." (Found on page 2 of 5 in the guide3_dem production PDF; First paragraph under the heading Generating the DTM/Mass Points).

Coplanarity Condition and Epipolar Alignment

"Perhaps the most fundamental and useful relationship in analytical photogrammetry is the collinearity condition. Collinearity is the condition that the exposure station, any object point, and tis photo image all lie along a straight line in three-dimensional space…" (Elements of Photogrammetry with Applications in GIS Fourth Edition; Page 268, Section 11-4 Collinearity Condition)

Orthorection Process

There are a few things that need to be done in the process of Orthorectifying your images, the following steps/process is what you need to do in order to orthorectify the images that you are working with. The first thing is to use the 20m DEM supplied to orthorectify all of the photographs in the block project. The default filenames are acceptable, but be sure to place the generated files into the ortho folder provided. or you can change the name of the filenames to the area that you are working with in.
The inherent spatial resolution of the photograph is approximately 0.5m (remember to click on *Use Current Cell Sizes* when adding the images to the processing list). In addition, since this is relatively high resolution imagery, the *Cubic Convolution* resampling method should be used to retain the sharpness of the image.
To automatically remove the "surround" information (fiducial marks, photo identifier, etc.) change the *Active Area* setting to 80%. This will result in the orthophotos containing only "useful" imagery. Finally, after the images have been added to the processing list click on the *Align Pixels* button to ensure they are all aligned to an even 0.5m pixel coordinate.

Figure 1

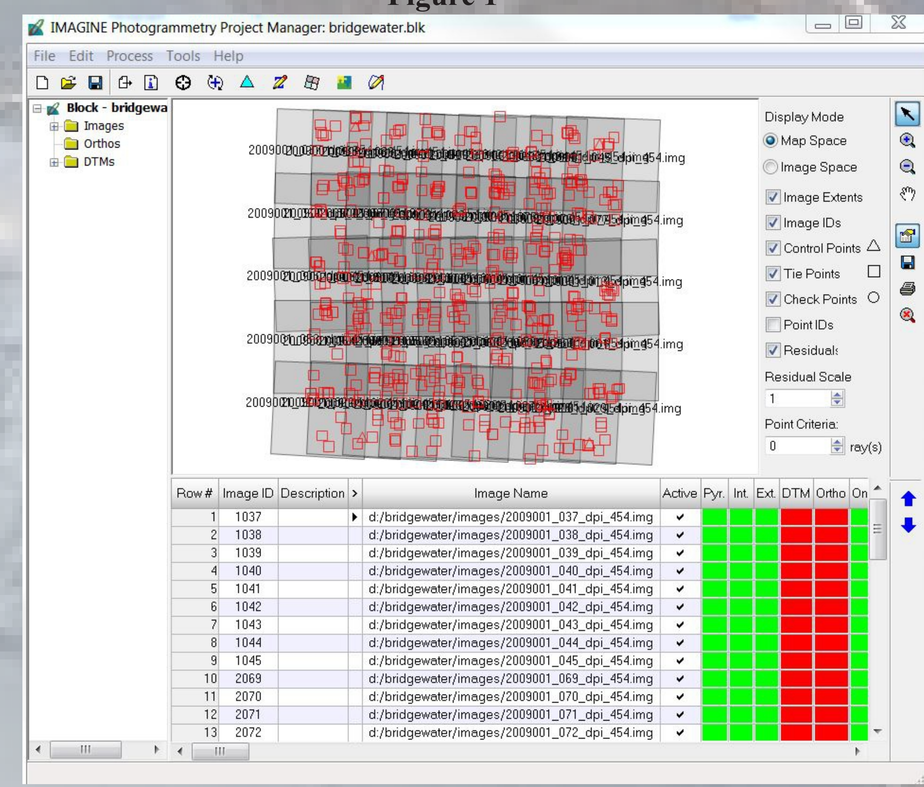

Figure 2

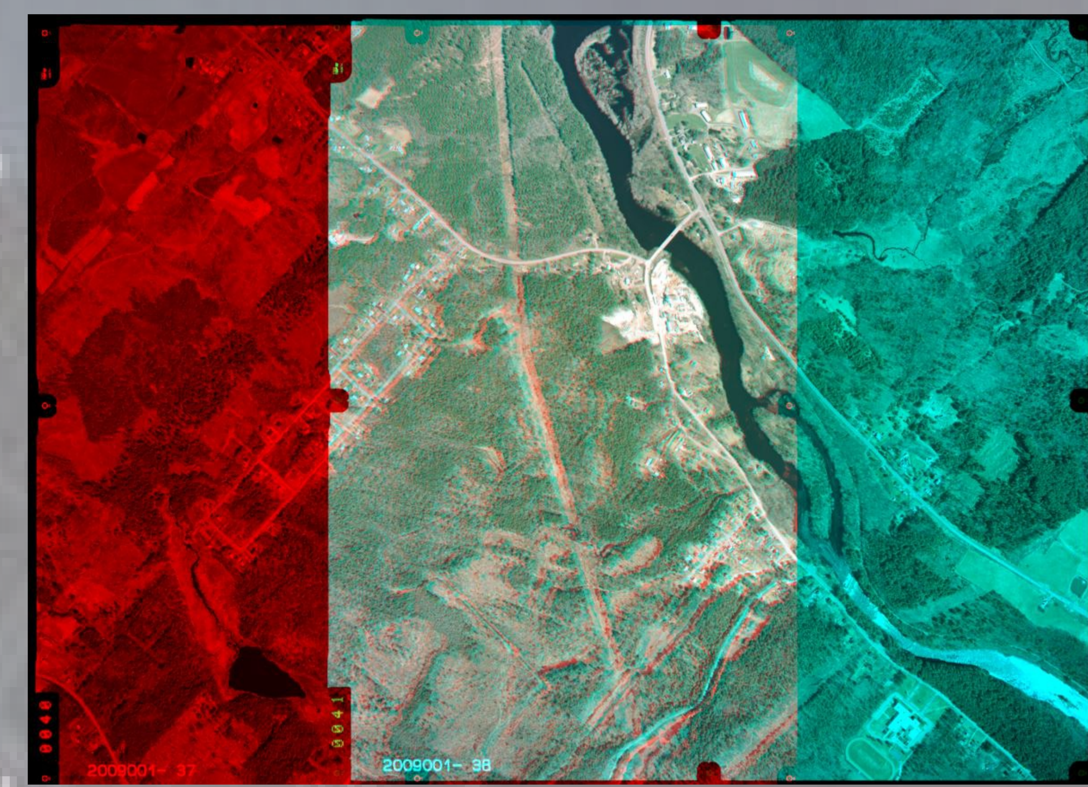

Figure 1 is showing what it looks like within IMAGINE Photogrammetry software, which can be found within the ERDAS IMAGINE software itself. This image is showing where all the Control points, Tie points, and Checkpoints were placed throughout the forty-five images that cover the Bridgewater area. The grey squares in the background are the showing how the images are lining up and you can also see the name of each image. In the list, that can be seen below the points and the images, is a list of the images that are being used within the bundle block. In this section of the window you can see which images are active within the block, which images have the pyramids computed, which images have their interior and exterior information set. The next column is to show which images have a DTM created. The following column is showing/telling you which images have orthorectified images. Then the final column is telling you if the image source link has been lost and you need to re-attach that image through the frame editor.

Figure 2 is showing what two images look like when brought into the Stereo Analyst software. This software allows you to view the image features in 3D. You first most line up the red image on the left and the blue on the right. Once you have them lined up and you put 3D glasses on then you will be able to see in 3D.

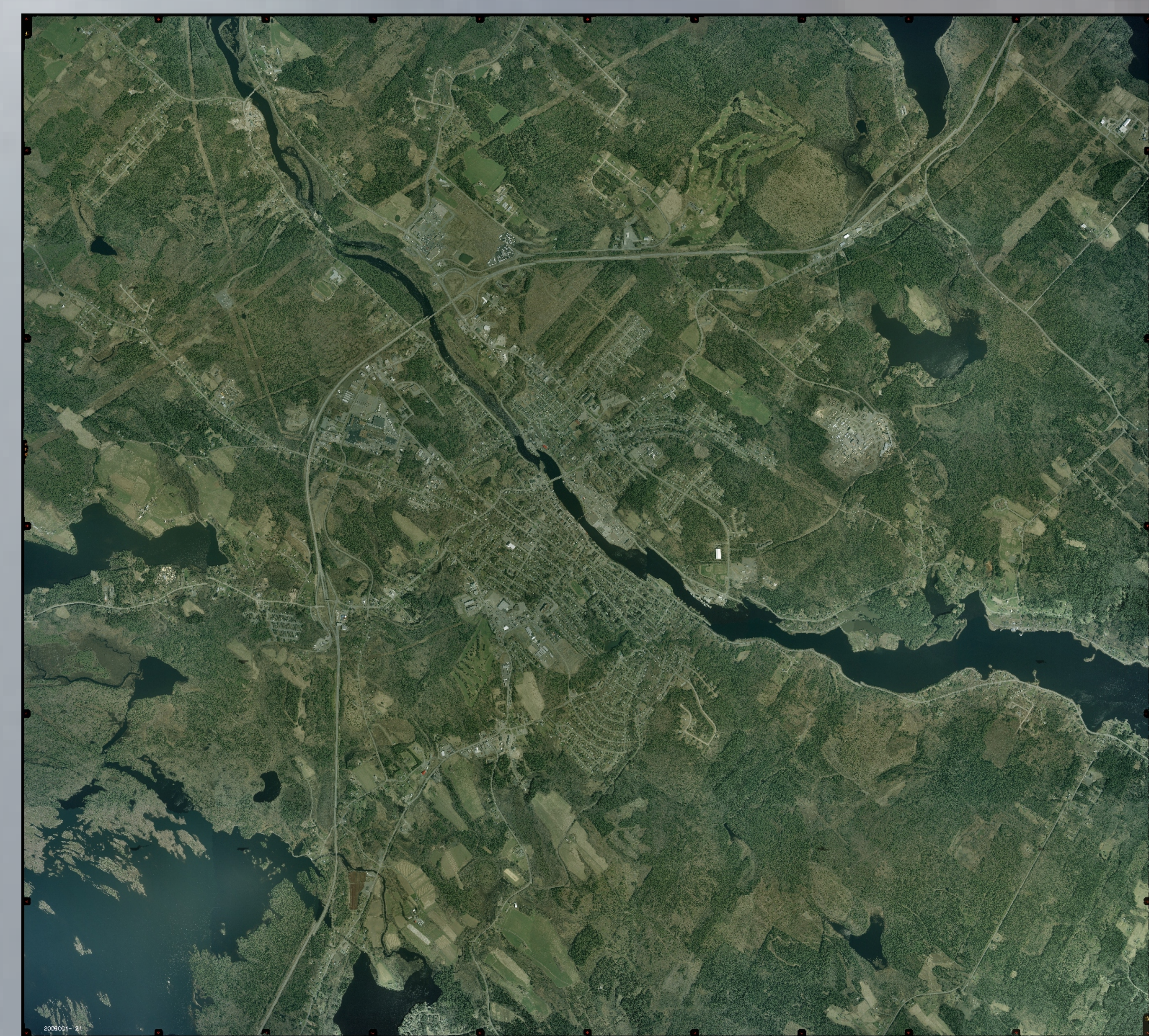

Figure 3

Figure 3 is showing what forty-five images look like once they have been orthorectified and then mosaicked together. When the mosaic is completed then there will be seam lines created and you can then edit those seam lines, so that the features line up better when you import your updated seam lines and then re-run your mosaic software on the forty-five images again.

Bibliography

Mikhail, E. M., Bethel, J. S., & McGlone, J. C. (2001). Introduction to Modern Photogrammetry. Toronto: John Wiley & Sons, Inc.

Slama, C. C., Theurer, C., & Henriksen, S. W. (1980). Manual of Photogrammetry. Virginia: American Society of Photogrammetry.

Wolf, P. R., Dewitt, B. A., & Wilkinson, B. E. (2014). Elements if Photogrammetry with Applications in GIS. Toronto: McGraw-Hill Education.

N/A. (2014, April 22). Interior Orientation. Retrieved from Hexagon Geospatial: https://wiki.hexagongeospatial.com/index.php?title=Interior_Orientation

Course PDFs that have been handed out by instructor.