DEM/ORTHO

Getting Started

Making DEMs and Orthophotos

with

TNTmips®

Before Getting Started

This booklet introduces techniques for extracting elevation raster objects (DEMs) from stereo imagery in TNTmips® and creating orthoimages by applying the elevation information to the source imagery. These processes are among the most powerful and complex in TNTmips and should not be casually approached by the beginner. This booklet shows how the basic steps work. It does not pretend to teach the complex science of digital photogrammetry.

Prerequisite Skills This booklet assumes that you have a fair amount of experience with TNTmips. At the minimum, you should have completed the exercises in *Getting Started: Displaying Geospatial Data, Getting Started: Navigating, Getting Started: Georeferencing,* and *Getting Started: 3D Perspective Visualization*. The exercises in those booklets introduce essential concepts and skills that are not covered again here.

Sample Data The exercises in this booklet use sample data that is distributed with the TNT products. If you do not have access to a TNT products CD, you can download the data from MicroImages' web site. In particular, this booklet uses objects in the AIRPHOTO, EPIPOLAR, DEM_TIN, and ORTHO Project Files in the DEMORTHO data collection. An option in the TNT installation process makes a read-write copy of these files on your hard drive; you may encounter problems if you work directly with the read-only sample data on the CD-ROM.

More Documentation This booklet is intended only as an introduction to DEM extraction and orthoimage creation. Consult the TNT reference manual for more information.

TNTmips and TNTlite™ TNTmips comes in two versions: the professional version and the free TNTlite version. If the software license key for the professional version is not attached to your computer, TNT operates in TNTlite mode, which limits object size and enables data sharing only with other copies of TNTlite.

DEM extraction and orthoimage creation are not available in TNTedit or TNTview. The processes are available in TNTlite, but the TNTlite size limits make it hard to provide real-world sample data that produces meaningful results. The sample data used in the exercises in this booklet exceed the TNTlite size limits.

Keith Ghormley, 21 September 2000

It may be difficult to identify the important points in some illustrations without a color copy of this booklet. You can print or read this booklet in color from MicroImages' web site. The web site is also your source for the newest Getting Started booklets on other topics. You can download an installation guide, sample data, and the latest version of TNTlite:

http://www.microimages.com

Making DEMs and Orthophotos

All airphotos contain systematic distortions caused by camera angle, distance, and surface elevation. As a result, their internal geometry differs from the ideal geometry of map products and therefore they are of limited use in professional geospatial analysis. In some cases, simple resampling and warping processes can produce corrections that are "good enough." But a more rigorous solution is to use digital photogrammetric techniques to create **orthophotos**, which have map-like geometry. Orthophotos provide an accurate image base for many projects in geospatial analysis.

The Photogrammetric Modeling process in TNTmips produces orthophotos in five steps:

- Georeference
- Interior Orientation
- Relative Orientation
- DEM Extraction
- Orthorectification

This booklet introduces each step of the process.

Please note that in one sense there is no such thing as "getting started" with digital photogrammetry in TNTmips. Photogrammetric Modeling is no place for beginners. Ideally, you would be well schooled in the principles of photogrammetry before you sat down at a computer. If you lack a university level background in photogrammetry, you should not expect to follow the examples and exercises in this booklet easily.

A series of intermediate results are included in the sample data, so you will be able to continue with the sequence of exercises, even if you are not able to produce usable results with the previous exercise. Don't be discouraged. But neither should you proceed with naive hopes of learning an easy way to do digital photogrammetry.

A **DEM** (Digital Elevation Model) is a raster object that contains elevation values for a site.

An **orthophoto** is a digital image that has been processed to correct for distortions of camera perspective and surface elevation. An orthophoto has map-like geometry and is useful as an accurate image base for geospatial analysis.

An **epipolar** image pair has been resampled to have the same cell size, and rotated so that all stereo parallax is in the horizontal dimension.

A **TIN** (Triangulated Irregular Network) is a set of 3D nodes connected by edges to form a network of triangles. TINs are fast, efficient structures for representing elevation surfaces.

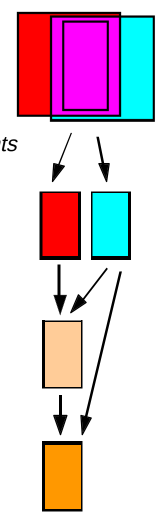
The exercise on page 5 discusses georeference. Page 6 presents interior orientation. Pages 7-9 cover relative orientation. Pages 10-15 introduce DEM Extraction. Pages 16-18 discuss orthoimage creation and evaluation.

Stereo to DEM to Orthophoto

The quality of the DEM produced by stereoscopic analysis is limited by the quality of the input stereo images. Clear, high-contrast images that have many widely distributed identifiable features are best. Images of large featureless regions of uniform landcover (such as flat agricultural fields) will usually not support detailed DEM output.

Overlapping airphotos contain stereo information that can be digitally processed to extract elevation information. The elevation information can in turn be used to adjust the position of features in the images to correct for systematic distortions caused by camera perspective and surface elevation. In uncorrected airphotos, tall features, nearer to the camera, are too big and appear to lean away from the center of the photo. After compensating for camera tilt, digital orthophoto techniques adjust the position of features inward and reduce their size, based on their elevation and their distance from the center of the photo.

Thus, if you have a pair of stereo airphotos, you can create a DEM and an orthoimage for the overlap area. Likewise, if you already have a DEM and one airphoto, you can create an orthoimage. And of course, if all you want is a DEM for your study site, you can create one from a pair of stereo airphotos and not bother with creating an orthoimage.



A pair of georeferenced **airphotos** with stereo overlap region

Relative Orientation

a small set of orientation tie points

Interior Orientation

Left-Right pair containing the extracted overlap region, processed to have **epipolar** orientation

DEM Extraction

a large set of parallax tie points

TIN and **DEM** extracted from the Left-Right epipolar pair

Orthorectification

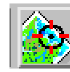
Orthoimage created from the DEM and any georeferenced image.

Be sure you make a read-write copy of the sample data on your hard drive. You cannot complete these exercises using the read-only sample data directly from the CD-ROM.

Prerequisite Georeference

Before you open the Photogrammetric Modeling process, you must prepare your input airphotos by establishing suitable georeference (Edit / Georeference). If you don't have georeference control, you can still extract relative elevation, but if you want real-world elevation values in the DEM, and if you want to produce an orthoimage, you must supply accurate map coordinates and elevation values.

As you enter map coordinates, be sure to enter an elevation value for each georeference point. In particular, enter elevation control points for the high and low features in the image. If you have a mountain top that is 5,000 meters, put a georeference point on that peak even if you must use estimated map coordinates (surround the mountain with low elevation control points of known coordinates, and then put a point on the peak using the Estimate Coordinates button and enter the known elevation of the peak).

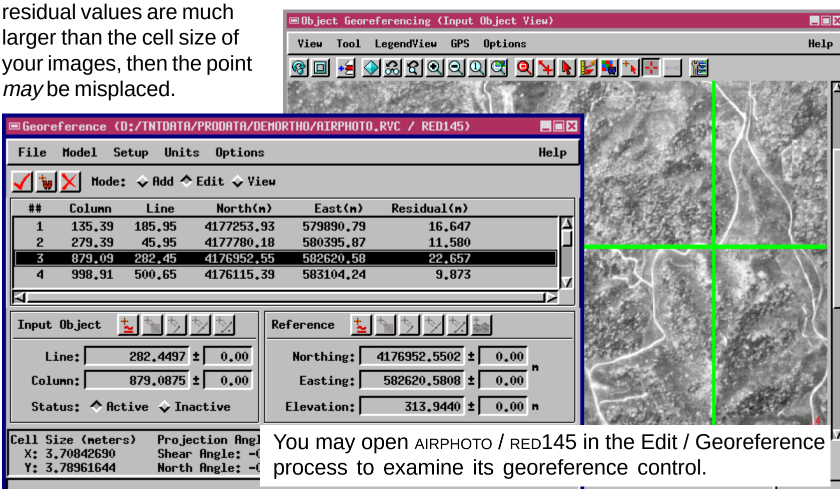


For help with the Georeference process, refer to the TNTmips reference manual, and to *Getting Started: Georeferencing*.

Consider: If you use an x-y digitizer with a 1:24,000 topo map for georeference control, then 1 mm on the printed map = 24 meters on the ground. So if your digitizer click is off by 1 mm and your airphoto cell size is between 3 and 4 meters, then your map control is accurate only to 6 to 8 pixels (worse if you account for the accuracy standards of the printed map).

Examine your georeference points for accuracy. If your residual values are much larger than the cell size of your images, then the point *may* be misplaced.

Every georeference point must have an elevation value associated with it. In particular, put georeference points on the extremes of high and low elevation in the scene.



You may open AIRPHOTO / RED145 in the Edit / Georeference process to examine its georeference control.

Interior Orientation

STEPS
- ☑ launch the Photogrammetric Modeling process
- ☑ choose Interior Orientation from the Mode option button
- ☑ for the left image, select RED145 in the AIRPHOTO Project File
- ☑ select RED146 for the right image
- ☑ examine the Focal Length, Scanner Resolution, and Principal Points addresses in the Camera Parameters tab

Interior Orientation requires only that you enter the orientation parameters. There is no associated processing operation with this step.

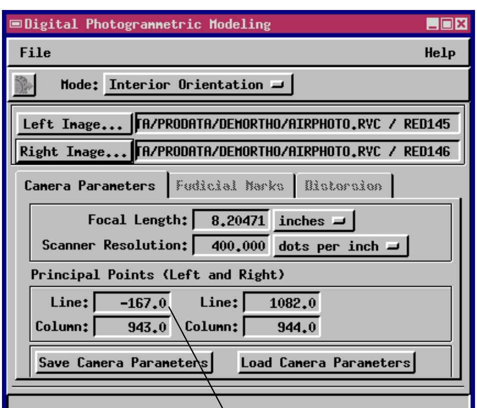
In the Camera Parameters tab, record focal length, scanner resolution and Principal Point addresses.

The DEM extraction and orthoimage creation process is found on the TNT menu path Process / Raster / Photogrammetric Modeling.

The first information the DEM and orthophoto process needs is used to establish the interior orientation of the georeferenced input airphotos. The process must know

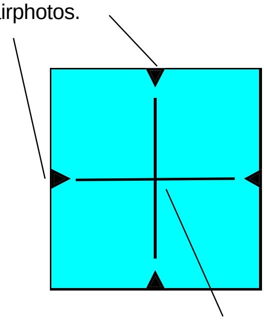
- the focal length of the camera lens that was used to collect the images,
- the scanner resolution used to digitize the photos, and
- the cell address of the principal point.

With full airphotos, use Display / Spatial Data to examine the airphotos to determine the cell address of each fiducial mark, and then calculate the cell address of the Principal Point. (If the fiducial marks are on the edges, then the column address of the Principal Point is halfway between the column addresses of the top and bottom fiducial marks; the line address of the Principal Point is halfway between the line addresses of the left and right fiducial marks.)



The sample data is cut out from a full airphoto, so the coordinates of the principal point reflect its location outside the extents of the raster.

Fiducial marks show as pinholes on the edges or in the corners of airphotos.



The **Principal Point** is the address of the cell where lines that connect opposite fiducial marks intersect.

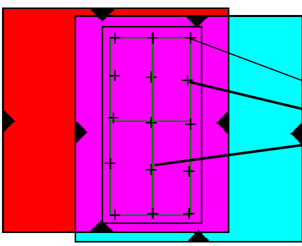
Tie Points for Relative Orientation

You will enter tie points at two stages of the Photogrammetric Modeling process. You must manually enter the first, smaller set of **orientation** tie points on the airphotos to provide information for the Relative Orientation step. Later, you can use a combination of automatic and manual methods to generate a much larger set of **parallax** tie points on the Left-Right epipolar images.

The goal in placing orientation tie points is to establish the rectangular extents and common orientation of the overlap area in the airphotos. Put tie points on common features in the corners, edges, and on the center lines of the overlap area.

STEPS

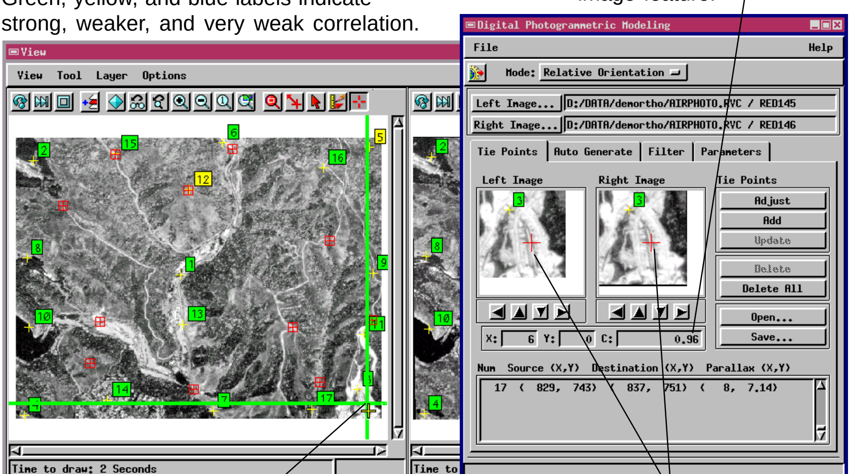
- ☑ choose Relative Orientation in the Mode option button
- ☑ click [Open...] in the Tie Points tab
- ☑ select the ORIENTATION tie point subobject that is offered
- ☑ turn on the Show Georeference Points and Show Color Coded Correlation toggles in the Parameters tab
- ☑ click Redraw in the View window



Put orientation tie points on common features in the corners, edges and center lines of the stereo overlap area.

The correlation value shows how well the immediate area around a tie point matches statistically in the two images. Add tie points only if they have a strong correlation value (aim at first for 80% or higher) AND clearly are positioned on the same image feature.

Green, yellow, and blue labels indicate strong, weaker, and very weak correlation.



To place a new tie point, (1) click on the left image in the View window, (2) adjust the crosshair position in the magnifier windows, and (3) click the Add push button.

Adjusting Orientation Tie Points

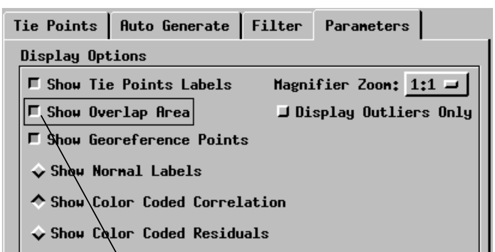
STEPS
- ☑ turn on Show Overlap Area in the Parameters tab
- ☑ add tie points outside the overlap box if you want to expand its extents
- ☑ click [Adjust All Tiepoints] on the Auto Generate tab
- ☑ manually adjust tie point positions if necessary
- ☑ click [Save...] to save revised tie point subobject

The orientation tie points you enter on the georeferenced airphotos are used to produce the LEFT and RIGHT epipolar images, which form the foundation of all your later work. Evaluate the orientation tie points carefully to ensure that you get the best possible set.

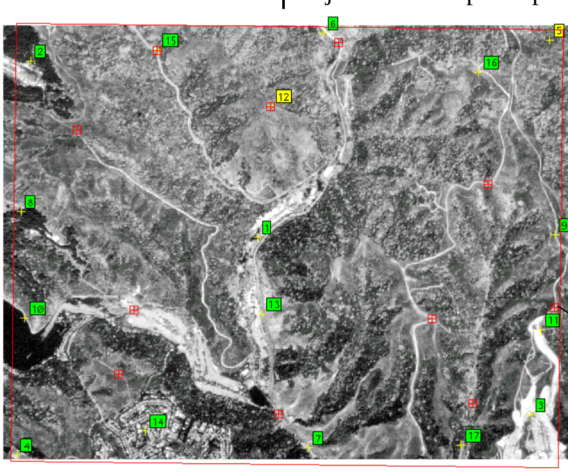
First, check the placement of the points and the red box that marks the overlap area (Parameters tab / Show overlap area toggle)

- If the box excludes part of the image you want to include, enlarge the box by putting tie points in the excluded area you want.
- If the box is skewed and has corners that are not at least approximately right-angled, then examine each tie point in your list: one or more are probably mismatched.

Use the Adjust All Tie Points push button in the Auto Generate tab to have the process automatically look for ways to improve the correlation by adjusting each orientation tie point. After the process adjusts the tie point positions, look again at the correlation values. If your tie points still have low correlation values, edit their position manually and then repeat the automatic adjustment procedure.



Turn on Show Overlap Area in the Parameters tab.



The red overlap area box should not be skewed and should have right-angle corners.

Process for Relative Orientation

After you have a good set of orientation tie points, you are ready to run the Relative Orientation process. Check to see that you have tie points around the perimeter of the area you want to process and that the overlap area box has square corners. Then click the Run icon button.

The Relative Orientation process extracts a raster pair from your source airphotos. The new LEFT-RIGHT pair is resampled to have the same cell size and rotated to have **epipolar** orientation.

The Relative Orientation process closes the input airphotos and automatically opens the new LEFT-RIGHT epipolar pair in the View window. When the process opens the new epipolar pair, it orients them so that cross-eyed stereo viewing is possible. As you add parallax tie points (refer to the next exercises), you can periodically look at the pair in cross-eyed stereo to make sure you are including the high and low points of elevation in the scene.

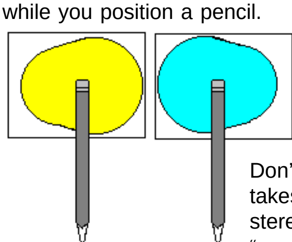
STEPS

- ☑ visually check the distribution of your tie points
- ☑ click the Run icon button 
- ☑ resize the View window to fit the aspect of the images, and attempt to view the new Left-Right epipolar images in cross-eyed stereo

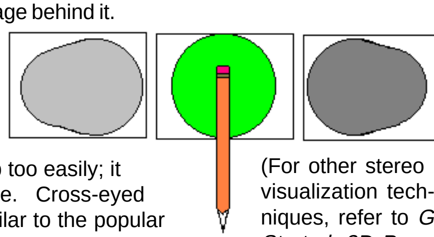
Human eyes do an excellent job of perceiving stereo information. If your imagery is too poor for stereo visualization, there is little chance that the photogrammetric modeling process will be able to identify and process enough image parallax to create a good DEM.

Cross-eyed stereo viewing is difficult for some people, but it can be a quick and useful technique, once you get the hang of it. If you don't know how to do cross-eyed 3D, try this: (1) hold a pencil a few inches in front of your nose as you look at the Left-Right epipolar stereo pair on the computer screen 20 - 25 inches away. While looking at the stereo pair, move the pencil forward and back until its unfocused, double image is centered in front of each image on the screen. (2) Then refocus your eyes on the pencil. The stereo images will appear to have a third image between them (directly behind the pencil). Keep your focus on the pencil, while you concentrate on the "middle" image. When your eyes adjust, the image should resolve into 3D and you can move the pencil out of the way. The trick is to hold the features in the "middle" image together against the tendency of your eyes to re-focus and let the stereo view slide apart into the discrete component pair again.

(1) Focus on the image pair while you position a pencil.



(2) Focus on the pencil, then on the "center" image behind it.



Don't give up too easily; it takes practice. Cross-eyed stereo is similar to the popular "magic eyes" 3D pictures and posters.

(For other stereo visualization techniques, refer to *Getting Started: 3D Perspective Visualization*.)

Parallax Tie Points for DEM Extraction

STEPS

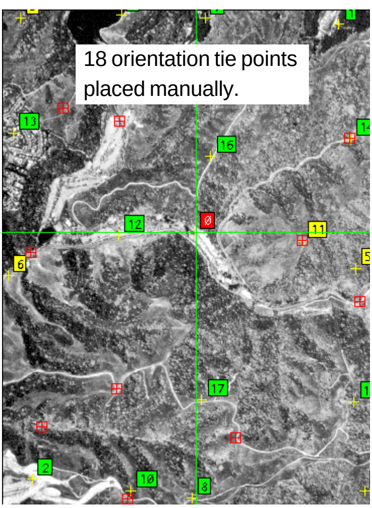
- ☑ turn off Show Overlap Area (Parameters tab)
- ☑ click [Open] in the Tie Points tab and select the TIEPOINT subobject
- ☑ click [Adjust All Tiepoints] on the Auto Generate tab
- ☑ add a tie point as near as possible to each georeference point
- ☑ click [Auto Generate Tie Points] in the Auto Generate tab

In some cases you may decide to disregard correlation values. For example, if an open water tank in a remote, featureless area shows clearly in both photos, it may make a good tie point, even if one photo has a sun flash on the water that gives the feature a very low correlation value.

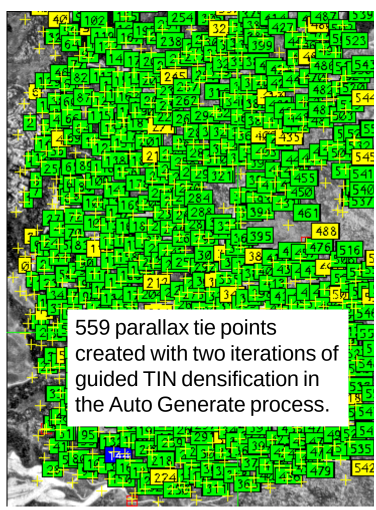
The Relative Orientation process created a LEFT-RIGHT epipolar pair of images that includes only the extents of the stereo overlap area. These new LEFT and RIGHT raster objects are loaded automatically as the input for the DEM extraction process.

You need a much larger set of parallax tie points for DEM extraction than you used for Relative Orientation. While the orientation tie points on the airphotos were placed in a regular pattern, around the edges and down the center lines, the parallax tie points on the epipolar pair are to be placed across the entire image, with special emphasis on elevation extremes in valleys and on ridges.

Open the tie point set that was carried forward from the Relative Orientation step (the new copy was automatically named TIEPOINT). Manually add tie points across the images, keeping an eye on the correlation value under the Right Image magnifier in the Tie Points tab, trying for tie points with an 80 percent or higher correlation to begin with.



18 orientation tie points placed manually.



559 parallax tie points created with two iterations of guided TIN densification in the Auto Generate process.

Iterative Generation of Parallax Tie Points

The Auto Generate feature allows you to create several generations of tie points using the TIN densification algorithm. In TIN densification, the process constructs a temporary TIN from the initial set of tie points. Then the process looks in the middle of each triangle on both images and searches locally for a new point of high correlation. If it finds a good point, the process adds it to the parallax tie point list and reconstructs the TIN.

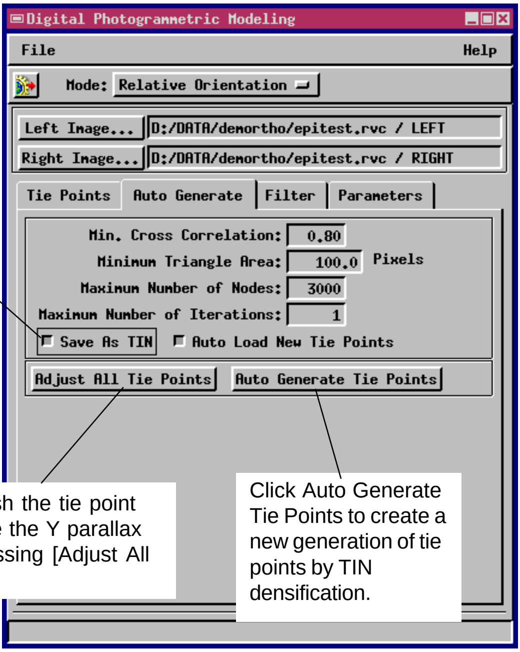
Click the Auto Generate Tie Points button in the Auto Generate tab to create a new generation of tie points. Unless you disable the Auto Load new Tie Points toggle in the Auto Generate Tab, the process automatically loads the new tie points, gives you the option of saving the previous set, and shows the new points in the View window. In the next two exercises, you will survey the distribution of the new tie points to look for areas that are sparsely populated, and you will also look at the Y residuals in the tie point list to identify tie points that are incorrectly placed.

STEPS

- ☑ turn on Show Color Coded Residuals in the Parameters tab
- ☑ if the tie point labels are all blue, click [Adjust All Tie Points] in the Auto Generate tab
- ☑ click [Auto Generate Tie Points] to create a second generation of tie points

TIN densification quickly generates many good parallax tie points. The process naturally concentrates tie points in areas with highly defined features while “avoiding” areas of uniform, featureless appearance.

The temporary TIN used in each iteration of the densification process can be saved after each run as a TIN object if you push in the Save As TIN toggle. Then you can view each TIN in Display / 3D Group to see how the surface looks so far.



You can refresh the tie point list and update the Y parallax values by pressing [Adjust All Tie Points].

Click Auto Generate Tie Points to create a new generation of tie points by TIN densification.

Evaluating and Adding Tie Points

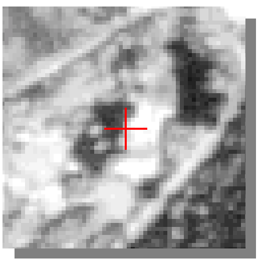
STEPS

☑ turn off the Show Tie Points Labels toggle in the Parameters tab

☑ select the Tie Points tab and manually add tie points in sparse areas

☑ click [Auto Generate Tie Points] in the Auto Generate tab

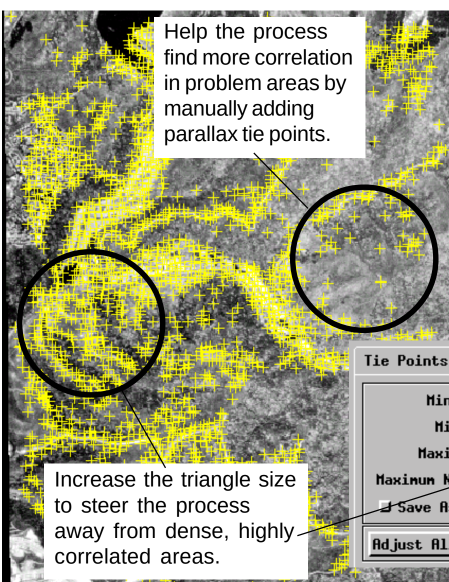
For tie point placement, pick features that have distinct patterns of light-dark boundaries, such as a bright rock outcrop in a darker vegetated area, or a dark tree in a light field.

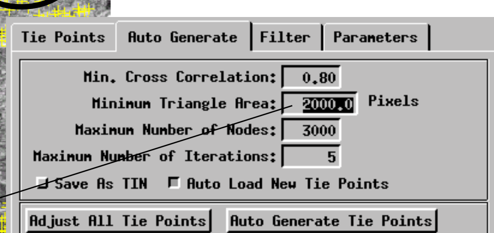


After each Auto Generate iteration, you may notice that new parallax points are concentrated in certain areas of the image, while other areas have been neglected. Not surprisingly, the TIN densification algorithm is very good at finding and following areas of strong correlation, and not as good at adding points to featureless areas of uniform texture and low correlation. Areas that have poor correlation, will have reduced detail and accuracy in the output DEM. (A poor DEM may still be suitable for Orthoimage creation, even though it may not be acceptable for other uses.)

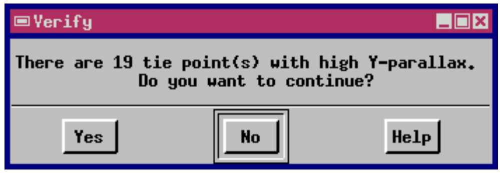
You can do two things to steer the process towards areas that need more parallax tie points. First, increase the Minimum Triangle Area to keep the process from adding more small triangles in densely correlated areas. Second, manually add tie points in the areas with few points. Your new tie points will force the process to look again in problem areas.

If you still aren’t getting enough points in difficult areas, decrease the minimum correlation value (Min. Cross Correlation) so that more tie points will qualify. Of course, if you lower the minimum correlation value too far, you may start getting false parallax points, which will give incorrect results in the DEM output.





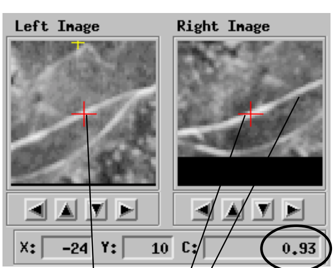
Correcting High Y Residuals



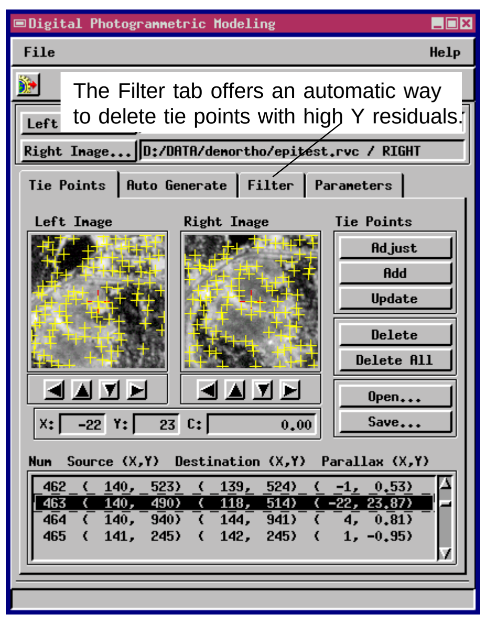
The essential quality of the epipolar Left-Right pair is that the stereo parallax is all located in the X dimension. Thus, the left-right stereo effect is created because the position of common features differs in only the horizontal direction. (All vertical displacement was minimized in the Relative Orientation step, which created the epipolar pair.) As a result, when you examine the parallax values in the tie point list, the parallax values should be very low (a cell or less) in the Y dimension. Any tie point that has a Y parallax larger than a couple of cells is almost certainly positioned incorrectly. If you try to run DEM Extraction with a set of tie points that includes such bad tie points, the process warns you of the problem with a Verify dialog box like the one illustrated at the top of this page. Do not proceed with the DEM Extraction step while your tie point list includes points with high Y-parallax. Select each bad point from the list, reposition it, click the Update button, and look at the new parallax value in the tie point list to be sure the point is now correctly placed.

STEPS
- ☑ scroll through the tie point list and select a high residual tie point
- ☑ manually correct its position
- ☑ click [Update]
- ☑ look for the next high-residual tie point

Points with high Y residuals must be deleted or corrected by adjusting their positions and clicking [Update].



93% correlation usually indicates a good tie point, but this diagonal road on a featureless background shows that high correlation does not always mean matching features.



Make TIN and DEM

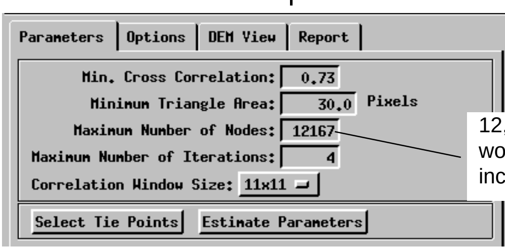
STEPS

- ☑ view one of your tie point TIN's (or DEM_TIN / TIEPOINT_TIN) in Display / Spatial Data / 3D
- ☑ choose DEM Extraction in the Mode option button
- ☑ click [Estimate Parameters]
- ☑ click [Save Result As TIN] in the Options tab
- ☑ select 16-bit signed integer as the Output Data Type in the Options tab
- ☑ click the Run icon button and create a new object for the output 

Once you have several hundred tie points, you are ready to run DEM Extraction. Before doing so, you can use the 3D Group display process to view the most recent TIN representation of the elevation surface (created by the Save As TIN toggle in the Auto Generate tab — see page 11). If you see obvious problems in the surface, go back to pages 12 - 13 and correct the related tie points.

Select the DEM extraction process by selecting DEM Extraction in the Mode option button. Click [Estimate Parameters] in the Parameters tab to have the process derive reasonable processing control values from the current tie point list. Select the Options tab and turn on the Save Result as TIN toggle, and change the Output Data type to 16-bit signed.

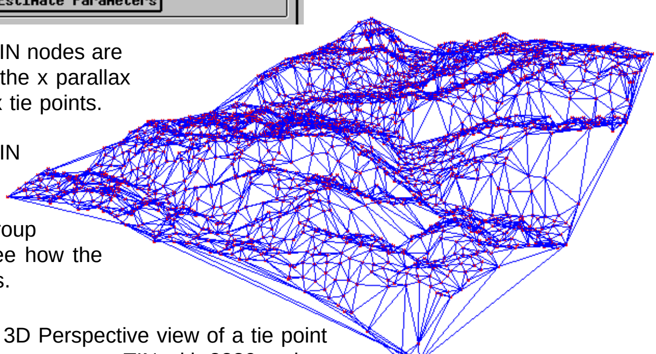
Click the Run icon button and when the process finishes, view the result in the DEM View tab.



12,000 nodes is enough for orthophoto work. To get sharper surface detail, increase the maximum to 40,000 or more.

The z values of the TIN nodes are derived directly from the x parallax values of the parallax tie points.

You can view each TIN object in the standard display process or the 3D Group display process to see how the current surface looks.



3D Perspective view of a tie point TIN with 2230 nodes.

NOTE: The Surface Fitting process (Process / Surface Fitting) offers a selection of additional methods for creating a DEM raster from the TIN object. For example, you could choose a high order polynomial fitting method to get a 64-bit floating point DEM with a continuous, curved surface.

Evaluate DEM

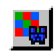
Pause at this point in the sequence to evaluate the DEM results. The orthorectification step will use the DEM to determine how far to move each pixel to produce the orthoimage. If that is your only consideration, then a DEM that shows sharp local detail is no better than a fuzzy low resolution DEM. More important than sharp local detail is how close the highest points in the surface are to the true elevation. If a mountain ridge of 1000 feet is represented by elevation values of only 800 feet, then the orthoimage result may be affected (the farther from the principal point, the worse the effect). But the presence or absence of local detail that depicts dendrite minutia of drainages has no measurable effect on the orthoimage. (Nevertheless, you may be interested in local elevation detail for other reasons.)

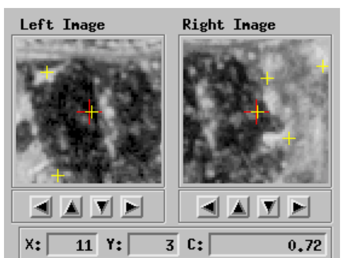
Use Examine Raster to check known points of elevation at several locations across the DEM, including valleys and ridges. The cell values of the DEM should be close to the known control values.

Select the Report tab and review the extraction summary statistics.

The orthoimage produced from the DEM created in these exercises shows corrections of up to 10 - 15 pixels. More local detail in the DEM would not improve the orthoimage.

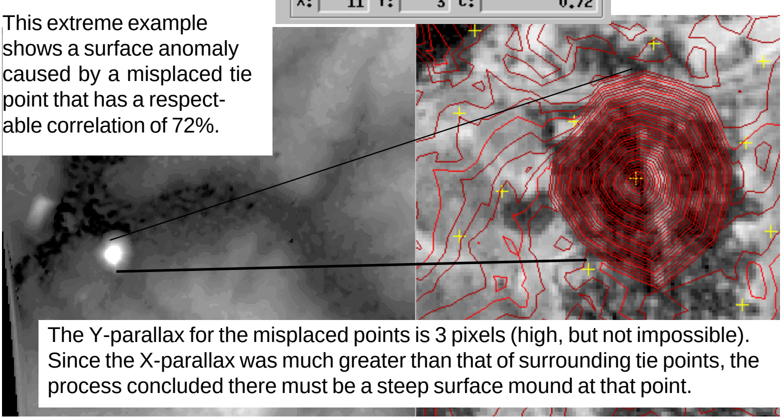
STEPS

- ☑ select DEM View tab
- ☑ visually inspect the overall DEM
- ☑ use Examine Raster in the DEM View tab to compare cell values to known points of elevation 
- ☑ correct any misplaced tie points (page 13) related to surface anomalies and re-run the DEM extraction process (page 14)



The tie point magnifier shows both the misplacement of the tie points and the similarity of light/dark image patterns that fooled the automatic tie point generation process.

This extreme example shows a surface anomaly caused by a misplaced tie point that has a respectable correlation of 72%.



The Y-parallax for the misplaced points is 3 pixels (high, but not impossible). Since the X-parallax was much greater than that of surrounding tie points, the process concluded there must be a steep surface mound at that point.

Orthorectification

STEPS

☑ select Orthorectification from the Mode option button

☑ select Left Image and DEM input raster objects and click [COMPUTE] to see the Orientation Statistics

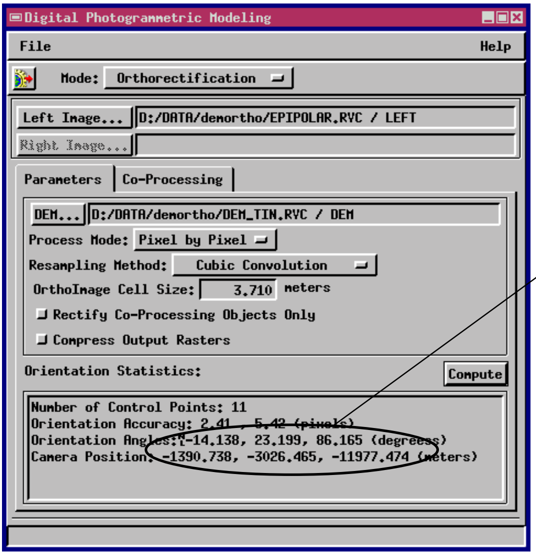
☑ if the process derives a workable orientation, click [Run] to create an orthoimage

Problems? Consider: If you use a 1:24,000 topo map for georeference control, then 1 mm on the printed map = 24 meters on the ground. So if your georeferencing digitizer click is off by 1 mm and your airphoto cell size is between 3 and 4 meters, then your original control is is accurate to 6 to 8 pixels at best.

Once you are satisfied with the DEM, you can apply it to either or both of the Left - Right epipolar images to create an orthoimage. Select Orthorectification from the Mode option button.

The orthorectification process is very sensitive to the georeference and orientation control associated with your images. After you select the input airphoto and DEM, the process displays the camera orientation statistics it derives. Even small errors in georeference control can result in unusable input objects. In particular, look at the Orientation angles: the camera is supposed to be pointing nearly straight down: so the first two values in the orientation angles should approach 0, 0 (the third angle is not critical).

Even though the input button is labeled “Left Image...” you can select any georeferenced airphoto that shares an overlap area with your DEM. Thus, if neither of your epipolar images work, try AIRPHOTO / RED146 with DEM_TIN / DEM from the sample data.



In this example, the first two computed camera rotation angles deviate radically from the ideal 0, 0 (“straight down”) orientation, so the process cannot proceed. As a side effect, the Camera Position values show a position *below* the surface. Even small errors and inaccuracies in georeference and orientation control can cause these values to jump out of useful ranges.

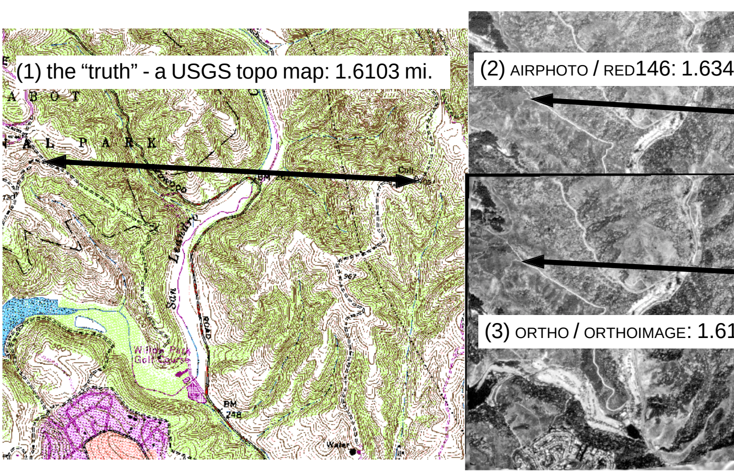
Evaluate Orthoimage

No map product is completely accurate at every point, so you should always do some evaluation to get an idea of the accuracy characteristics of your orthoimage. The kind of reference control you have available will determine the kind of evaluation you can perform. Ideally, you would compare the orthoimage coordinates reported for the cursor location in the display process with the coordinates of a number of accurate survey points that were not used as input control in the stereoscopic modeling process.

If you lack such control values for checking, you might be able to compare several sample measurements made on the airphoto and orthoimage with known distances from an accurate source. If the orthoimage measurement values are consitently better than the airphoto values, you may reasonably conclude that the geometry of the orthoimage is better than that of the uncorrected airphoto.

Adopt reasonable expectations and evaluation criteria for your results considering the accuracy and distribution of your georeference control, the quality of your input images, and the use you plan to make of the output raster objects.

Test measurements were made on three images to evaluate the orthoimage.



Not every test measurement compared as well. Nevertheless, all the ORTHOIMAGE measurements were closer to the values from the topo map than the RED146 values were.

What Went Wrong?

Inaccuracies in input control values almost always cause problems in the photogrammetric modeling process. The process must have good quality imagery and accurate geospatial control.

The DEM extraction process can produce impressive results for some types of input images. You can expect good results if your input images have large relief displacements and many high contrast features. You should NOT expect good results if your input images are of flat, featureless terrain that offers a uniform appearance, such as desert, pasture, or large agricultural fields.

Many of the questions new users ask do not relate to the TNTmips software, but to the science of digital photogrammetry. MicroImages can answer your questions about TNTmips, but our software support engineers cannot be expected to teach you a university course in photogrammetry.

Many users of TNTmips are attracted to the DEM and orthoimage process because it promises to deliver an accurate, digitally corrected image base for their project materials. Since orthoimages prepared by professional photogrammetrists can be prohibitively costly, the DEM and orthoimage capability in TNTmips looks like a bargain. Others are looking for ways to create reliable DEMs for areas where no other source of DEMs is available.

It sounds too good to be true. Unfortunately, for the naive user, it often is too good to be true. MicroImages has provided reliable and useful tools for making DEMs and orthoimages. However, the best tools cannot compensate for poor data or poor reference control.

New users contact MicroImages technical support with problems that stem from

- poor source images: grainy, low-resolution images, images that contain too little parallax, images that differ greatly in contrast and brightness (perhaps collected on different dates or under different circumstances);
- poor georeference control: control points with residuals many times greater than the cell size of the image; no control points on high-elevation features;
- poor tie point correlation: inability to place useful tie points in large featureless areas of the photos where even the human eye finds too little stereo information for 3D viewing;
- too few tie points for DEM extraction: blocky, low-resolution DEM results.

If you do not get impressive results on your first try, do not be discouraged. The DEM and orthophoto process is by nature very sensitive to the accuracy of input control values. Learn all you can about digital photogrammetry from university-level textbooks.

Frequently Asked Questions

Can the DEM/ortho process produce a contour map with one foot or one meter accuracy from 3-meter imagery?

No way. The DEM/ortho process uses concepts developed in the science of Photogrammetry, the science of making precision measurements from photographs. The key words here are “precision measurements.” 3-meter images are simply too coarse to achieve 1-meter results, no matter how you process them.

What are the main problems that I should anticipate?

The most common problem in the application of the DEM/ortho process is in the expectation that the source images and control data can produce results better than is photogrametrically possible. The number two problem is inaccurate ground control points and tie-points.

What features are planned for future versions of Photogrammetric Modeling?

A visual semi-interactive interface will be added for finding and measuring the position of fiducial marks on the input airphotos in order to compute location of the principal point. Another feature will remove distortion from the input images based on camera calibration data.

Can I get special help for my project?

Yes, within reason. MicroImages software engineers and support specialists regularly work with clients of all kinds. Please recognize that the DEM/ortho process is complicated and not easy to apply properly. One notable MicroImages client has persevered through several versions of the process to achieve impressive results creating a “DEM” and mosaicked orthoimages from video frames of an underwater archaeological site.

My DEM is fuzzy and doesn’t show much detail. Is it still useful?

It depends on the application. Detail in the DEM is not critical in the preparation of acceptable orthophotos, 3D views, and flybys. For those applications, as long as the extremes of elevation in the DEM are close to actual values, a fuzzy DEM is good enough. However, accurate detail in the DEM is more important for geomorphology (such as extracting drainage paths and watersheds), GIS (such as assigning Z coordinates and viewsheds), and engineering (such as cut and fill analysis, and gravity flow systems). So if your application requires sharper surface detail, increase the number of parallax tie points. The more tie points you get, the more local surface detail you will get. (Of course processing takes longer and eventually you will reach a point of diminishing returns.)

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