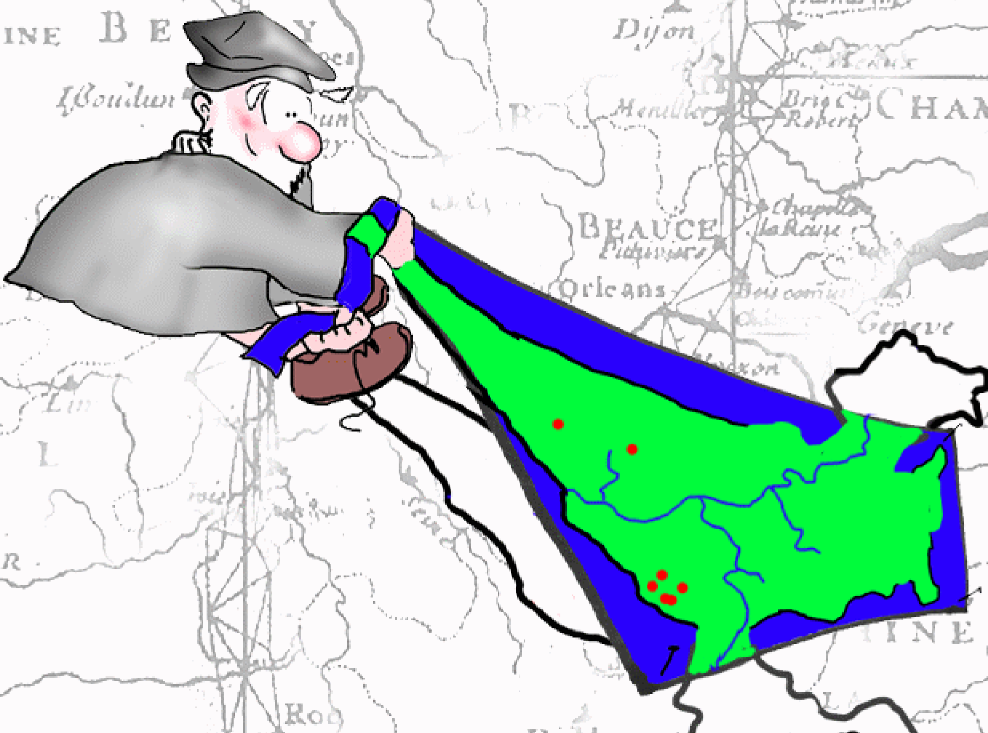
RECTIFCATION

Getting Started

Rectifying Images



with

TNTmips®

Before Getting Started

This booklet introduces you to the Automatic Resampling process in TNTmips®. This process uses georeference control point information to perform simple rectification of distorted images, and to transform a raster image into a desired geographic coordinate system. The exercises cover the various options for controlling the size, extents, and orientation of the rectified image, as well as different resampling methods and geometric transformation models. Warping of distorted vector or CAD objects is also briefly introduced.

Prerequisite Skills This booklet assumes that you have completed the exercises in *Getting Started: Displaying Geospatial Data* and *Getting Started: Navigating*. Those exercises introduce essential skills and basic techniques that are not covered again here. You will also find the concepts introduced in *Getting Started: Georeferencing* and *Introduction to Map Projections* to be helpful in understanding image rectfication. Please consult those booklets and the TNTmips reference manual for any review you need.

Sample Data The exercises presented 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 sample files in the RECTIFY and CB_DATA data collections.

More Documentation This booklet is intended only as an introduction to rectifying and resampling raster images. Consult the TNTmips reference manual, which contains more than 14 pages on the Automatic Resampling process, for more information.

TNTmips and TNTlite® TNTmips comes in two versions: the professional version and the free TNTlite version. This booklet refers to both versions as "TNTmips." If you did not purchase the professional version (which requires a hardware key), TNTmips operates in TNTlite mode, which limits object size and does not allow export.

The Automatic Resampling process is not available in TNTview or TNTatlas. All the exercises can be completed in TNTlite using the sample geodata provided.

Randall B. Smith, Ph.D., 27 August 2001

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.

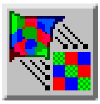
http://www.microimages.com

Welcome to Rectifying Images

In most geographic data sets it is useful to integrate planimetric map data with aerial or satellite imagery. A correctly processed digital map is free of significant geometric distortion and conforms to the projection and coordinate system of the original map. Raw digital images, on the other hand, are not aligned with any conventional geographic coordinate system, and they commonly contain internal geometric distortions that result from the image acquisition process. These distortions can arise from tilt of the sensor plane, variations in sensor altitude, Earth curvature, lens distortion, and terrain relief, among other causes. As a result the raw images do not have a simple "map-like" geometry, and accurate map relationships cannot be derived from them.

The Automatic Resampling process (sometimes called warping or "rubber sheeting") changes or rectifies the geometry of a raster image using the locations of ground control points that provide georeference control for the image. Depending on the geometric transformation model you select, the process can remove or reduce internal geometric distortions in the image and reorient and differentially rescale it so that the lines and columns in the output raster are parallel to the axes of a specific geographic coordinate system. Each input raster is processed separately and each must be georeferenced. Control points must be accurately located, sufficient in number for the transformation model selected, and distributed uniformly across the image.

Image rectification is not required in all instances. Satellite imagery of low-relief areas may have minimal internal distortions. The Spatial Data Display process in TNTmips can overlay georeferenced layers with different map projections and coordinate systems with reasonable registration. However, if these raster layers will be used together routinely, resampling to a common map projection can significantly speed up display times.



STEPS
☑ start TNTmips
☑ select Process / Raster / Resample / Automatic from the main menu

For the sake of brevity, and because multiple input rasters are processed separately, discussions of the resampling process in the remainder of this booklet refer to "the input raster" and "the output raster", regardless of the number of rasters being used.

The exercises on pages 4-9 introduce the Automatic Resampling process, and demonstrate various options for determining the cell size, orientation, and extents of the output raster. Pages 10-11 discuss the three options for interpolating the cell values in the output raster. Geometric transformation models are discussed on pages 12-17. Vector warping is covered on page 18, and a review and references are found on page 19.

To simply rescale, rotate, or flip a raster image without reference to geographic coordinates, use the Raster Extract process (Process / Raster / Extract), which allows these operations via the controls on the Zoom / Orient tabbed panel.

Automatic Raster Resampling Window

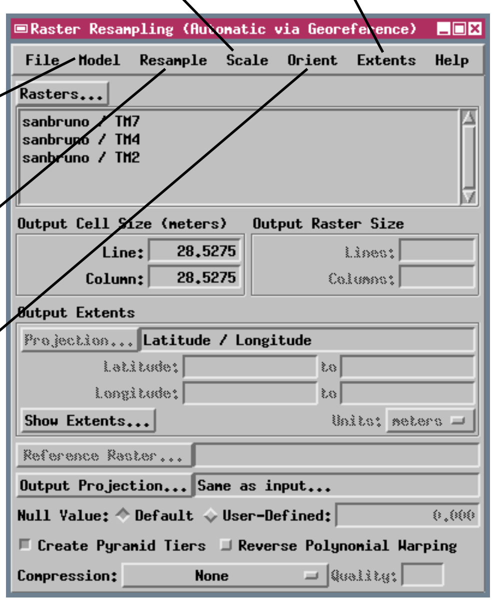
STEPS
- ☑ click [Rasters...] on the Raster Resampling window
- ☑ use the standard File / Object Selection window to select objects TM7, TM4, and TM2 from the SANBRUNO Project File in the RECTIFY data collection
- ☑ select From Georeference from the Model menu
- ☑ select Nearest Neighbor from the Resample menu
- ☑ select By Cell Size from the Scale menu
- ☑ select To Projection from the Orient menu
- ☑ select Entire Input from the Extents menu

The Raster Resampling window provides the controls necessary for the Automatic Resampling process. Most resampling options are set using the menus at the top of the window. Choices on these menus set the methods for determining the scale, orientation, and geographic extents of the output raster, as well as the geometric transformation model and the method for interpolating output cell values. You may have found that the choices specified in the step list on this page were already selected; these are the initial default selections for each menu. However, if you make a different choice from a menu, that choice is saved as the default selection for the next session. Always check each of the parameter menus to confirm that your desired menu choice is selected.

Use the standard display process (Display / Spatial Data) to view the input and output objects for these exercises.

Choices on the Scale menu determine the method used to scale the output raster.

The Extents menu provides several methods for setting the geographic extents of the output raster.



The Model menu provides a choice of different geometric transformation models.

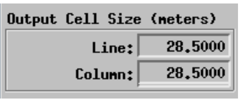
Use the Resample menu to choose one of three methods for interpolating cell values for the output raster.

The Orient menu offers options for orienting the output raster relative to the output projection.

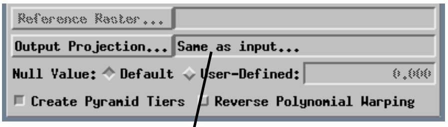
Keep the current settings and continue to the next page.

Rectifying to the Input Map Projection

You will probably use the Automatic Resampling process most often to transform a georeferenced raster into the coordinate system and map projection specified in its georeference subobject. To do so, use the default choice on the Orient menu (To Projection), and the default Output Projection option (Same as input...). Horizontal lines of cells in the output raster are then parallel to the x axis of the input geographic coordinate system, and vertical columns are parallel to the y coordinate axis. The input rasters used in this exercise are extracts of a Landsat Thematic Mapper scene georeferenced to the Universal Transverse Mercator coordinate system, so the output raster set is aligned to the UTM system.



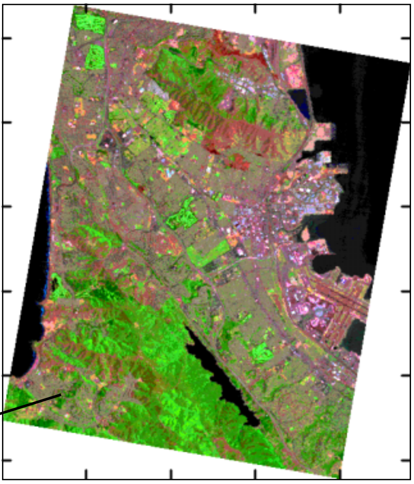
STEPS
☑ in the Output Cell Size text fields, enter 28.5 for both the Line: and Column: settings
☑ choose Run from the File menu
☑ use the standard File / Object selection procedures to name a new Project File and the output raster objects



Use the default Output Projection option to warp the input raster into the projection specified in its georeference subobject.

When you choose By Cell size as the scale option, you must enter line and column cell size values (in meters). The cell size, geographic extents, and output projection then determine the number of lines and columns in the output raster. In this exercise, we preserve the 28.5-meter spatial resolution of the original imagery in the resampled output set.

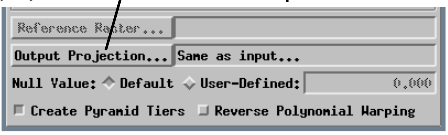
RGB display of input raster set with R = TM7, G = TM4, and B = TM2.



Output raster set (warped and reoriented to the UTM coordinate system), displayed with UTM grid tick marks along the border for emphasis.

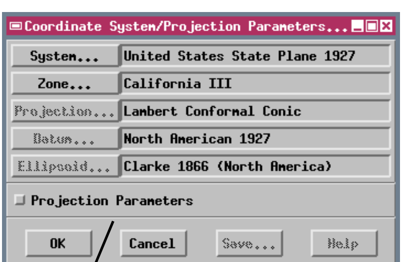
Warping to a New Map Projection

Clicking the Output Projection button opens the Coordinate System / Projection Parameters window, which allows you to choose a different output projection.



STEPS

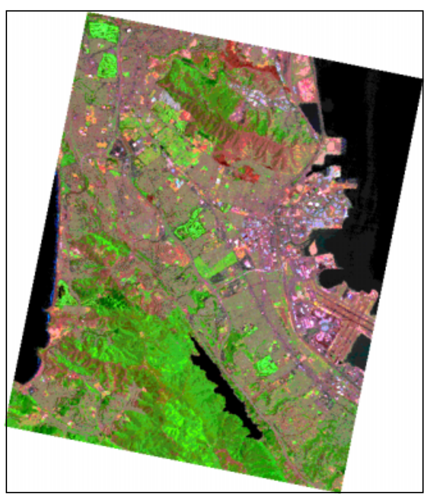
- ☑ click [Output Projection...]
- ☑ in the Coordinate System / Projection Parameters window, click [System...]
- ☑ choose United States State Plane 1927 from the Coordinate System window, then click [OK]
- ☑ click [Zone...]
- ☑ choose California III in the Zone Selection window, then click [OK]
- ☑ click [OK] in the Coordinate System / Projection Parameters window
- ☑ choose Run from the File menu, and name the output raster objects



Use of the Coordinate System / Projection Parameters window and the associated concepts are introduced in the *Introduction to Map Projections* booklet.

You can also warp the input raster to a coordinate system and map projection other than the one in which it is georeferenced. Use the Coordinate System /Projection Parameters window to choose from among several predefined coordinate systems, or use the User Defined coordinate system option, which allows you to select a specific map projection and projection parameters. In this exercise the input raster set is reoriented to the State Plane 1927 coordinate system.

Warping a raster to a map projection commonly results in a significant rotation of the image, as well as other internal changes in its geometry. If you warp the entire image (as in this exercise), the image edges are not parallel to lines and columns in the output raster. The warped and rotated image is embedded in a raster that is somewhat larger than the original, with triangular "blank" (nonimage) areas at the corners. (The blank areas are assigned the null value so they can be rendered transparent when the raster is displayed.)



Output raster set in the State Plane 1927 coordinate system.

Warping to a Reference Raster

A raster that is already aligned to a geographic coordinate system can be selected as a Reference Raster to control the cell size, orientation, and/or extents of the output raster created by the resampling process. Scale and orientation are linked in this instance; choosing Match Reference from the Scale menu automatically selects To Reference on the Orient menu (and *vice versa*). With these options selected, the output raster assumes the cell size and orientation of the reference raster.

You can use the Match Reference option on the Extents menu to trim the output image to the exact extents of the reference raster. This is an appropriate choice if the reference raster is wholly contained within the area of the input raster image (as in this exercise). If the reference and input rasters only partially overlap, you may want to select the Overlap Reference option to output only the area common to both.

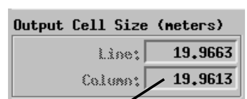
STEPS

☑ choose Match Reference from the Scale menu

☑ choose Match Reference from the Extents menu

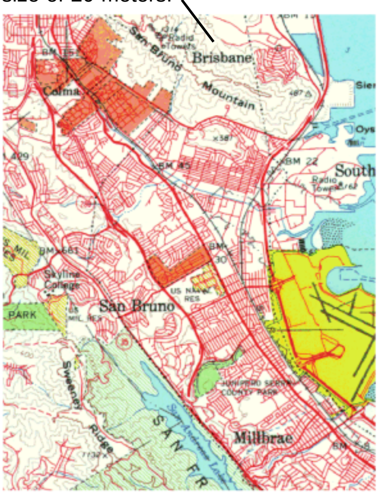
☑ click the Reference Raster button and select the MAP object from the SANBRUNO Project File

☑ run the resampling process



The output cell size is set automatically when you use a reference raster to control the scale and orientation of the output. The reference projection overrides any previously selected output projection.

Reference raster MAP, aligned to the UTM coordinate system, with a cell size of 20 meters.



Raster set resampled using the reference raster to specify scale, orientation, and output extents.

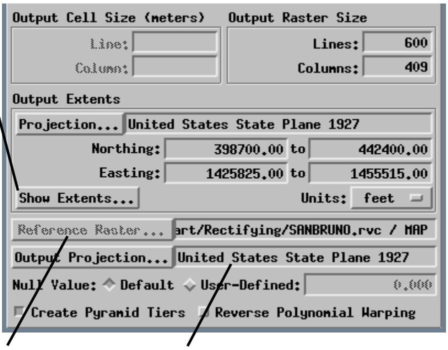
Setting Output Extents and Raster Size

STEPS
- ☑ choose To Projection from the Orient menu
- ☑ choose By Raster Size from the Scale menu
- ☑ enter 600 in the Line field and 409 in the Column field in the Output Raster Size panel
- ☑ choose User Defined from the Extents menu
- ☑ click [Projection...] on the Output Extents panel
- ☑ use the Coordinate System / Projection Parameters window to select United States State Plane 1927 as the System and California III as the Zone
- ☑ in the Output Extents panel, select Feet from the Units option button
- ☑ enter the following extents ranges: Northing: 398,700 to 442,400; Easting: 1,425,825 to 1,455,515
- ☑ run the resampling process

We have covered several options for specifying the extents of the output raster, including Entire Input, Match Reference, and Overlap Reference. The final option is User Defined. When you select this option from the Extents menu, the Output Extents panel becomes active. The text fields in this panel allow you to enter exact geographic extents for the output raster, using any available coordinate system. Latitude / Longitude is the default system. Click the Projection button on the Output Extents panel to open the Coordinate System / Projection Parameters window to select an alternate system.

In some instances you may want the output raster to have a specific size in lines and columns. The By Raster Size option on the Scale menu provides this capability. The line and column cell sizes are then determined by the raster size and output extents.

Click [Show Extents...] to open a window showing the geographic extents of the input raster.



The reference raster used in the last exercise is still selected and available for use. However, the Reference Raster button is dimmed, showing that the raster is not in use with the current settings. The previously-selected State Plane output projection is once again active.

Output rasters in State Plane 1927 coordinate system, with extents specified in the Output Extents panel. Compare with image on page 6.

Choose File / Exit when finished with this exercise.

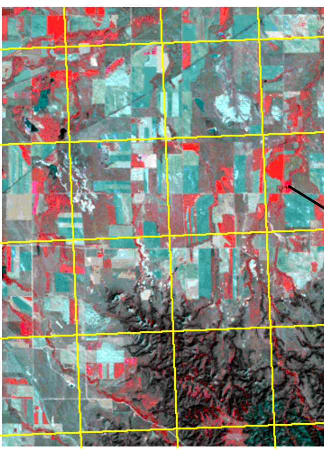
Orienting to a Direction

The vertical axis of an input raster's map coordinate system (such as State Plane or UTM) may not be parallel to the local direction of true north. The Orient menu allows you to use the georeference information to align the output raster with any of the four cardinal compass directions at the top. These options are most useful when the input raster is already aligned with a map coordinate system, and you want to reorient it with north at the top.

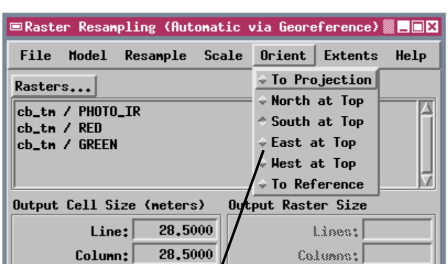
In this example, the edges of the input raster set coincide with lines of equal latitude (horizontal) and longitude (vertical), so it is already oriented with north at top. Reorienting it to the State Plane projection would cause a clockwise rotation of a few degrees. Reorienting it with South at Top exactly inverts the image.

STEPS

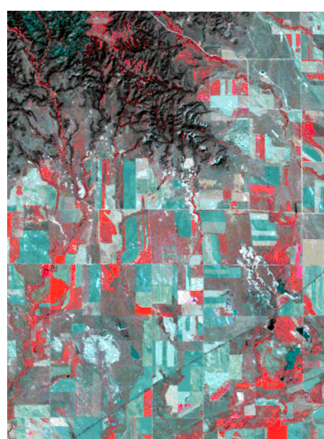
- ☑ restart the Automatic Resampling process
- ☑ click [Rasters...] and select objects PHOTO_IR, RED, and GREEN from the CB_TM Project File in the CB_DATA data collection
- ☑ select By Cell Size from the Scale menu
- ☑ in the Output Cell Size text fields, enter 28.5 for both the Line and Column settings
- ☑ choose Entire Input from the Extents menu
- ☑ select South at Top from the Orient menu
- ☑ run the resampling process



RGB display of input raster set (R = PHOTO_IR, G = RED, and B = GREEN) with a 10,000 foot State Plane Coordinate map grid in yellow.



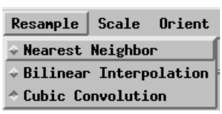
You can orient the output raster with any of the four cardinal directions at the top.



Output raster set reoriented with south at top.

Cell Value Interpolation in Resampling

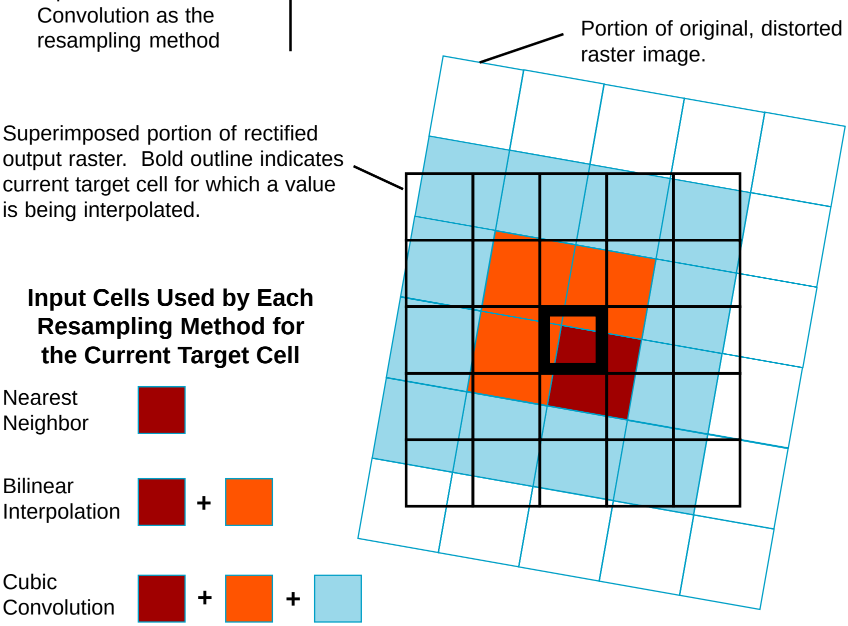
STEPS
- ☑ click [Rasters...] and select object PAN from the SANBRUNO Project File
- ☑ in the Output Cell Size panel, enter 2.00 in both Line and column text fields
- ☑ select To Projection from the Orient menu
- ☑ make sure that Nearest Neighbor is still selected in the Resample menu
- ☑ run the resampling process



- ☑ select Bilinear Interpolation from the Resample menu and run the process again
- ☑ repeat with Cubic Convolution as the resampling method

The Automatic Resampling process uses several steps to create the transformed output raster. First, the geometric transformation procedure (described subsequently) creates a “blank” rectified raster with the proper extents and scale (cell size). Then a cell value is determined for each cell in the rectified raster. To do so, the geometric transformation is reversed for each output cell in order to determine its position in terms of the original raster line and column coordinates. The target output cell may be larger or smaller than an input cell, and it may overlap several input cells. The output cell value must therefore be calculated (interpolated) from some combination of the surrounding input cells.

The Resample menu offers three options for interpolating output cell values: Nearest Neighbor, Bilinear Interpolation, and Cubic Convolution. These methods are illustrated in the diagram below and are discussed on the next page.



Resampling Methods

Nearest Neighbor Each output cell value in the nearest neighbor method is the unmodified value from the closest input cell. Less computation is involved than in the other methods, leading to a speed advantage for large input rasters. Preservation of the original cell values can also be an advantage if the resampled raster will be used in later quantitative analysis, such as automatic classification. However, nearest neighbor resampling can cause feature edges to be offset by distances up to half of the input cell size. If the raster is resampled to a different cell size, a blocky appearance can result from the duplication (smaller output cell size) or dropping (larger cell size) of input cell values.

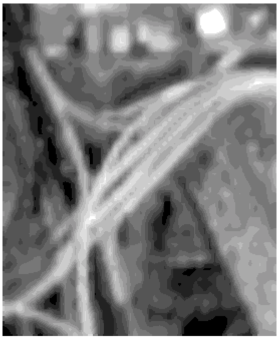
Bilinear Interpolation An output cell value in the bilinear interpolation method is the weighted average of the four closest input cell values, with weighting factors determined by the linear distance between output and input cells. This method produces a smoother appearance than the nearest neighbor approach, but it can diminish the contrast and sharpness of feature edges. It works best when you are resampling to a smaller output cell size

Cubic Convolution The cubic convolution method calculates an output cell value from a 4 x 4 block of surrounding input cells. The output value is a distance-weighted average, but the weight values vary as a nonlinear function of distance. This method produces sharper, less blurry images than bilinear interpolation , but it is the most computationally intensive resampling method. It is the preferred method when resampling to a larger output cell size.

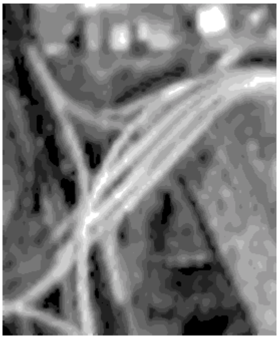
Nearest neighbor resampling is the only method that is appropriate for categorical rasters, such as class rasters produced by the Automatic Classification process. Cell values in these rasters are merely arbitrary labels without numerical significance, so mathematical combinations of adjacent cell values have no meaning.

Raster PAN resampled from a cell size of 10 meters to 2 meters using three resampling methods.

Nearest Neighbor



Bilinear Interpolation



Cubic Convolution

Rectifying a Color Infrared Airslide

STEPS:
Use the Display process to examine the following:

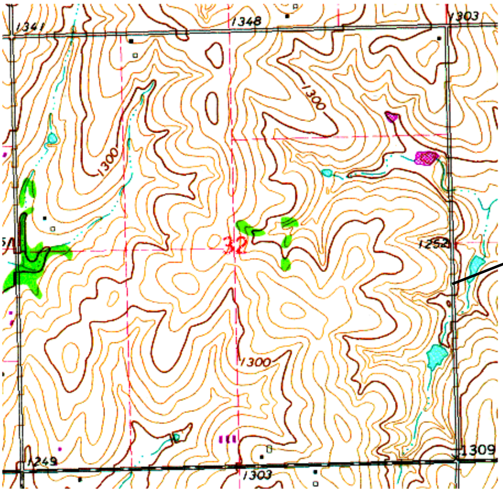
- ☑ RGB display of objects NIR, RED, and GREEN from the SECT32 Project File in the RECTIFY data collection
- ☑ single-raster display of object SECTMAP in the SECT32 Project File

The remaining exercises use a color-infrared airslide of a mile-square section of agricultural and residential land in eastern Nebraska. The airslide exhibits several types of distortion, and the exercises examine the effects of different geometric transformation models in attempting to rectify this image.

Color infrared photo of Section 32 with locations of ground control points used for georeferencing. The image was georeferenced to the UTM coordinate system using a UGSG Digital Orthophoto Quad image with 1-meter cell size.

The northern and southern section lines are not parallel in the photo, and appear to converge toward the west (compare with the map below). This indicates that the camera was not pointed straight down, but was tilted slightly toward the west when the photo was taken.

Several of the section lines also are curved outward slightly. Some of the areas of curvature coincide with topographic ridges, suggesting that this is an effect of relief displacement. Some of the outward curvature may also be a radial distortion resulting from imperfections in the camera lens.



Topographic map (object SECTMAP) covering Section 32, resampled to conform to the UTM coordinate system. Note the nearly square shape defined by the roads bounding the section. The residential development in the southeastern quarter of the section was not present when this map was compiled.

Geometric Transformation Models

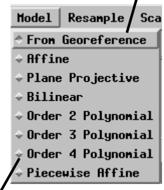
To alter the geometry of the input raster, the Automatic Resampling process analyzes the locations of the ground control points that were assigned in the georeference process. These are points in the image with known coordinates in a standard geographic reference system. The process compares the geographic coordinates of the control points to the locations predicted by the geometric transformation model you have selected. The results are used to determine numerical coefficients for coordinate transformation equations that convert the original distorted image to the desired geographic coordinate system.

The Automatic Resampling process incorporates all of the geometric transformation models that are available in the Georeference process for assessing the quality of control point locations. Each transformation model requires a minimum number of control points for solution. The minimum number of control points provides a single, unique solution, but any errors in control point locations directly impact the transformation. If additional control points are available, the process computes a best-fit transformation using least squares adjustment. This procedure chooses the set of coefficients for which the sum of the squared residual errors (deviations between predicted and actual locations in the final coordinate system) is a minimum.

The quality of the rectification result depends on the number, accuracy, and distribution of the control points and the choice of transformation model. Care in the georeference process is the best guarantee of success in rectification. Position control points so that they cover most of the image. Adjust control point positions to minimize the residual values (error estimates resulting from the least squares adjustment) for each control point. Appropriate uses for each transformation model are discussed on the following pages.

STEPS
- ☑ click [Rasters...] and select objects NIR, RED, and GREEN from the SECT32 Project File
- ☑ choose Cubic Convolution from the Resample menu
- ☑ select Match Reference from the Scale menu
- ☑ click [Reference Raster...] and select object SECTMAP from the SECT32 Project File

The From Georeference option selects the transformation model that was saved with the control point locations in each object's georeference subobject. This choice potentially allows different transformation models to be applied to different raster objects in the input list.



Each of the other model choices is applied globally to all input raster objects, regardless of the model used in the georeference process.

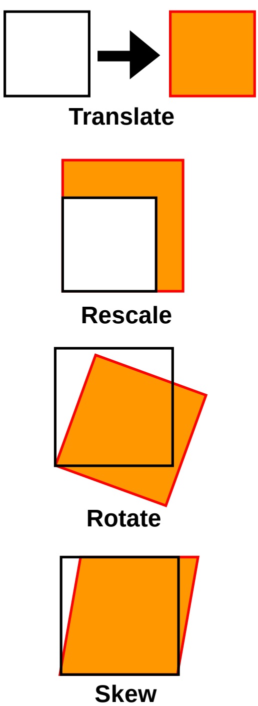
Keep the current settings and proceed to the next page.

Affine Model

STEPS
- ☑ choose Affine from the Model menu
- ☑ run the resampling process

In this and the following exercises we process the entire input image, but use the SECTMAP raster to control the cell size and orientation of the output image. The image is resampled from a cell size of about 3.37 m to an output cell size of 4.0 m.

Affine Transformations



The affine transformation model projects coordinates from one plane (defined by the original coordinate system) to another *parallel* plane (defined by the output coordinate system). An affine model can incorporate any or all of the transformations illustrated: translation, rescaling, rotation, and skew (or shear) of the image. Rescaling can accomodate a separate scale factor for each of the two coordinate axis directions. Any set of parallel lines in the source image remain parallel in the output image. The affine model requires a minimum of three control points that do not fall on a single straight line.

The affine model is appropriate when you need to convert a planimetric map raster (or an already-rectified image) from its original coordinate system and map projection to a new planar coordinate system (for example, UTM to State Plane coordinates). It may also give satisfactory results if you are rectifying a vertical aerial or satellite image of a small area with little topographic relief (so that the surface approximates a plane, and there is little or no tilt displacement or relief displacement).

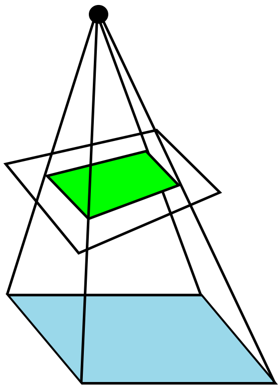
The affine transformation rotated and rescaled the CIR image, but did not correct the curvature and convergence of the section lines (the effects of more complex tilt distortion and relief displacement).

Plane Projective Model

The plane projective model transforms coordinates between any pair of source and target planes, including *nonparallel* planes. It employs a perspective projection: projection lines linking input and output coordinate locations emanate from a single central view point, analogous to the real location of a camera or other sensor. For this reason, the plane projective model is commonly used to rectify nonvertical aerial images of relatively flat terrain.

The plane projective model incorporates all of the transformations found in the affine model. However, the only lines that remain parallel in both the distorted and rectified images are those that are parallel to the line of intersection between the two planes. The plane projective model requires a minimum of four noncolinear control points.

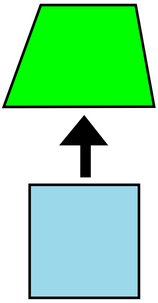
STEPS
- ☑ choose Plane Projective from the Model menu
- ☑ run the resampling process



The plane projective model transforms coordinates in one plane to another nonparallel plane using a perspective projection.

The plane projective transformation corrected the tilt distortion found in the original image. The north and south section lines are now nearly parallel. However, the subtle curvature of these lines shows that some distortion arising from relief displacement and/or lens effects still remains. Distortion due to relief displacement is relatively minor for this image because vertical relief is small (about 110 feet) compared to the image's horizontal dimensions.

Oblique perspective view of a square results in a trapezoidal shape. The plane projective model can rectify this simple tilt distortion.



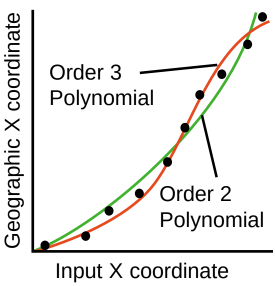
Polynomial Models

STEPS
☑ choose Order 3 Polynomial from the Model menu
☑ run the resampling process

The minimum number of required control points increases with the polynomial order:

Order 2: 6 control points
Order 3: 10 control points
Order 4: 15 control points

Hypothetical plot of input versus output control point position in one direction, illustrating fit with polynomials of different order.



The Polynomial transformations can correct *nonlinear* distortions in a raster image, as well as the linear distortions handled by the models discussed previously. Polynomial equations are used to relate control point positions in the distorted image coordinates to corresponding positions in the output geographic coordinate system. The control point information is used to calculate a best-fit set of coefficients for the terms in the equations. The *order* of the polynomial model is the highest exponent used in the equations, and specifies the allowed complexity of the fit, as shown for one direction in the illustration below left.

An Order 2 polynomial describes a fit with one sense of curvature (concave or convex) in any direction. This model can correct for radial lens distortion, or distortion arising from curvature of the Earth in high-altitude or satellite scenes of large areas. An Order 3 polynomial allows one change in sense of curvature in any direction, and an Order 4 polynomial allows for an even more complex fit. These models can correct more complex image distortions, but may introduce distortion in areas between control points, especially around the edges of the image.

Polynomial transformations of the test image produce very similar results for all three orders, probably because of the small image area, dense network of control points, and small amount of terrain distortion. The Order 3 polynomial appears to produce the best result (shown here), comparable to the result from the plane projective transformation. Several of the section lines are still bowed outward, an indication of uncorrected terrain distortion.

Piecewise Affine Model

The transformation models discussed previously all compute a global best-fit solution for the entire image. They are best tailored to remove smoothly varying distortions. Distortions that change significantly over small areas are not corrected. In fact, a local distortion that affects the positions of one or two control points will influence the overall fit as much as other correctly modeled points. As a result, the local distortion introduces a smaller component of distortion throughout the entire rectified image.

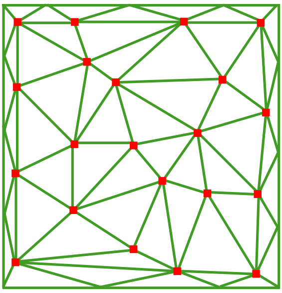
The Piecewise Affine model offers an alternative approach. Each control point is assumed to be in the correct position, and the points are used to segment the image into a network of triangles. An affine transformation is then computed separately for each triangle. A single distorted control point location only affects the immediately surrounding triangles. At least six control points are required, but larger numbers produce better results.

STEPS

☑ choose Piecewise Affine from the Model menu

☑ run the resampling process

Example image partitions using the control points for the test image.



The Delauney triangulation procedure is used to compute the optimum triangular network, with some extrapolated boundary points added for completeness.

The Piecewise Affine transformation of the test image produces a slight improvement over all of the previous methods. Because of the large number of control points and the gentle relief, the method is able to correct some of the terrain distortions, producing straighter section boundaries. This method is also useful for rectifying scanned map mosaics that were assembled from pieces with various sources and scales (such as some property maps).

The highly localized and variable relief displacement distortion found in aerial images of high-relief areas cannot be corrected using the Automatic Resampling process. Rectification of these images to a map geometry (orthorectification) requires the use of stereo images or an accurate digital elevation model (DEM). See *Getting Started: Making DEMs and Orthophotos* for more information.

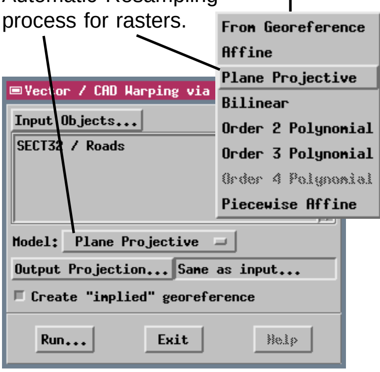
Warping Vector or CAD Objects

STEPS
- ☑ select Process / Vector / Warp from the TNTmips main menu
- ☑ in the Vector / CAD Warping window, click [Input Objects...]
- ☑ select vector object ROADS from the SECT32 Project File
- ☑ choose Plane Projective from the Model option button
- ☑ click [Run] and name the output object

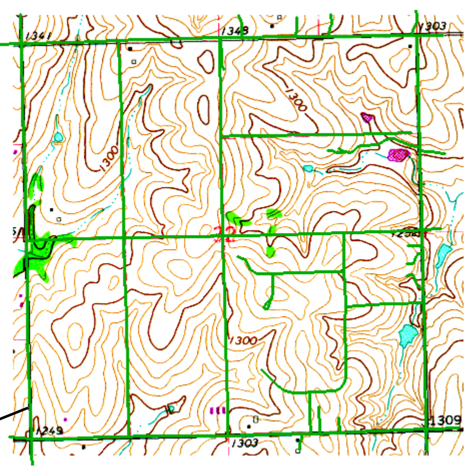
The Vector Warping process provides the same transformation models that are available in the Automatic Resampling process for rasters.

If a vector (or CAD) object is created from a distorted, nongeoreferenced raster image, the resulting object incorporates the spatial distortions of the parent object. These distortions remain even after georeference control points are assigned to the vector object. The Spatial Data Display process in TNTmips can rectify a vector object with control-point georeferencing on the fly (using the Warp to Model option on the Vector Object Display Controls window), but redisplay times may be long for a large vector object.

The Vector / CAD Warping process permanently rectifies a distorted vector or CAD object, producing an output object aligned to the selected projection, with element locations specified in the corresponding geographic coordinate system. The input object must have discrete georeference control points, rather than implied georeferencing. All of the geometric transformation models discussed previously are also available for rectifying vector and CAD objects.



The ROADS object was created in the Object Editor by tracing the roads and fence lines from an ungeoreferenced version of the raw SECT32 image. It was then georeferenced to UTM using a USGS Digital Orthophoto Quad image.



Vector object ROADS after warping to UTM using the Plane Projective model, displayed with green line color over the SECT32 map object.

A better strategy is to georeference and rectify source imagery *before* creating a vector overlay. The vector object is then automatically georeferenced and aligned to the desired coordinate system and projection.

Review and References

There are several common situations in which you should use the Automatic Resampling process:

- to remove or reduce certain types of simple geometric distortions from aerial or satellite imagery, producing a more map-like image geometry.
- to reproject a set of georeferenced raster images to a common map projection, coordinate system, and cell size to facilitate spatial analysis, classification, change detection in multidate imagery, or other scene-to-scene comparisons of individual cell values. This includes scanned topographic and planimetric maps which have been georeferenced, but are not yet aligned to the desired coordinate system.

You do *not* need to resample component images before making a mosaic unless different images exhibit different types of distortion. The Mosaic process applies a single selected geometric transformation model to rectify all georeferenced images to a common output projection and coordinate system.

Successful rectification begins with careful georeferencing of the images. You need to determine the types of distortion present in the image and choose the appropriate geometric transformation model. Use this model in the georeference process to evaluate residual errors in control point locations, and again in the Automatic Resampling process for the actual rectification.

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RECTIFICATION

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