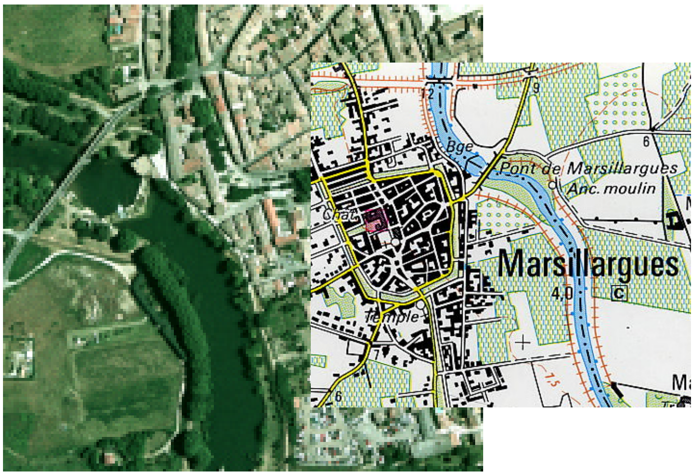
Tutorial on Geometric correction



Public Health Mapping
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Why correcting raster?

Raster data is commonly obtained by scanning maps or collecting aerial photographs and satellite images. In order to use these types of raster data in conjunction with other spatial data, it is often needed to georeference it to a map coordinate system.

When you georeference or orthorectify raster, you define how the data is situated in map coordinates. This process includes assigning a coordinate system that associate the data with a specific location on earth. This transformation of raster data allows it to be viewed, queried, and analyzed with other geographic data. Geometric correction includes the following steps :

- ✓ Choosing a map coordinate system
- ✓ Transforming the raster with a geometric model
- ✓ Resampling the raster

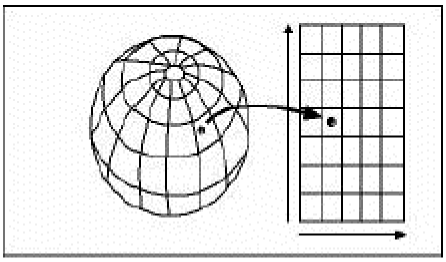
Choosing a map coordinate system

The choice of the map coordinate system depends on the final use of the raster data. The system used is generally the same as existing spatial data on the area of interest.

In the case of map presentation using a medium scale (1/50.000 to 1/250.000) or a large scale (1/10.000 to 1/50.000), a topographic map will be used as a reference for geometric transformations. In other words, a scanned map will be used to take ground control points. In this case, the coordinate system of reference will be the coordinate system of the topographic map. The output coordinate system of your raster can be different from the coordinate system of reference.

The coordinate systems

A cartographic projection is a representation of earth surface on a map. This representation is called planimetric model. This representation allows the transfer of each point of the earth surface on a map. The geographic coordinate system is a latitude and longitude coordinate system. The projected coordinate system represents the projection of a geographic coordinate system onto a plane. Coordinate systems based on Universal Transverse Mercator (UTM) projections is an example of projected coordinate system. The coordinates of a projected coordinate system are popularly given as (x,y).

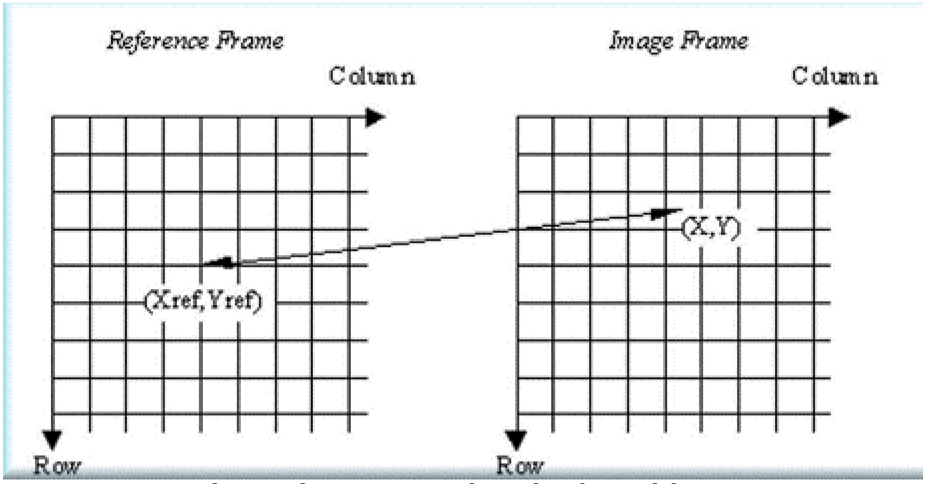


X and Y projection

More than 400 different projections exist. This great number is due to the fact that none of the projected coordinate systems can preserve the geometric properties (direction, distance and area) of the earth surface. Consequently, each country has developped its own coordinate system depending on its position on the globe and on map scale.

Transforming the raster with a geometric model

After collecting ground control points (GCPs), you can transform or warp the raster to map coordinates. Warping uses a mathematical transformation to determine the correct map coordinate location for each cell in the raster.



Ground Control Points are used to solve the model equations

The polynomial model is the most simple model and can handle most of the georeferencing requirements. A first order polynomial transformation will shift, scale and rotate your raster. It can be used to rectify scanned maps or satellite images on flat areas.

The geometric models

Different geometric models exist to transform raster images to map coordinates. The image resolution, the scale of the reference (map, vector file or georeferenced image) and the relief of the area are to be considered when choosing a geometric model. For medium resolution image on flat areas, the polynomials models are sufficient. In the case of images with large geometric distortions, the orthorectification method is necessary in order to reduce the distortion due to the relief or the viewing angle. An orthorectification process takes into account the conditions of data acquisition (position of the satellite, specifications of the camera, etc.)

Number of points

For a first order polynomial model, a minimum of three ground control points is required to calculate the model. In practice, it is better to collect more than three points. Given only three, if one point is positionally wrong, it has much greater impact on the transformation. Thus, even though the mathematical transformation error may increase as you collect more points, the overall accuracy of the transformation will increase as well.

The root mean square error

The degree of which the transformation can accurately map all control points can be measured mathematically by comparing the actual location of the map coordinate to the transformed position in the raster. The distance between these two points is known as residual error. This value describes how consistent the transformation is between the different control points.

Rectifying the raster

After calculating the transformation model, you can rectify the image in the map coordinate system. Resampling is the final step of geometric correction. Different resampling methods can be used in the rectification methods.

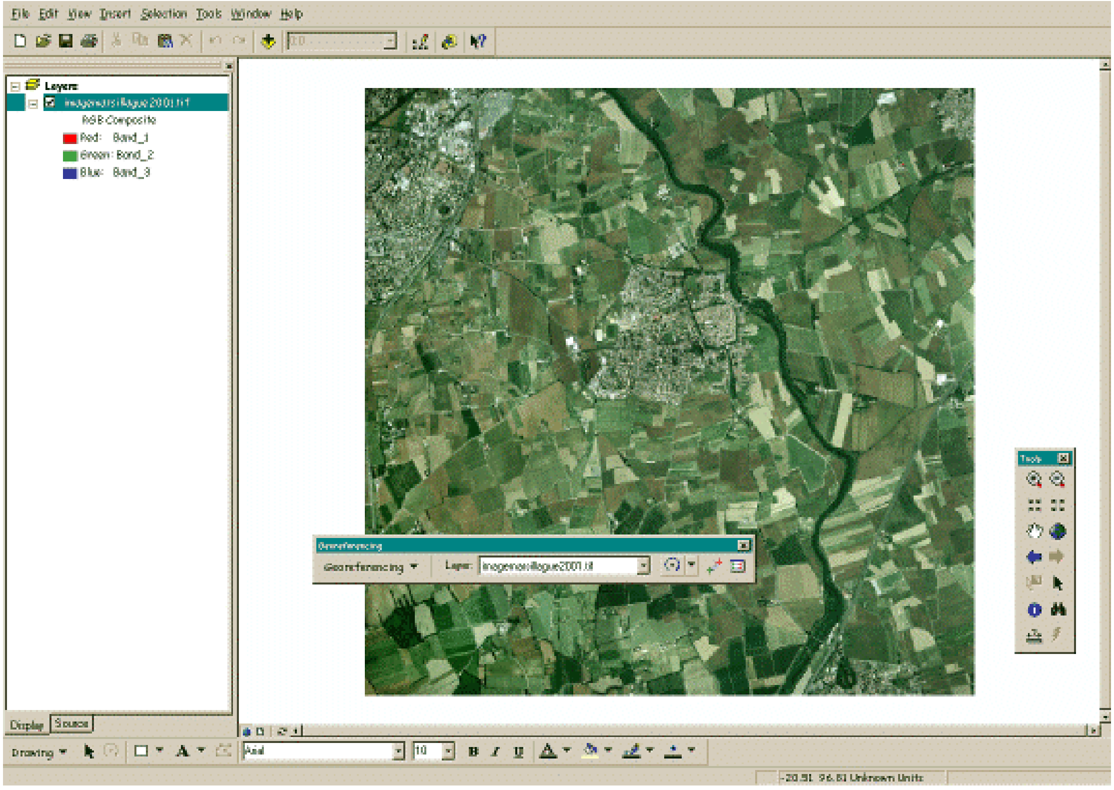
The resampling methods

The three most common resampling methods are nearest neighbor assignment, bilinear interpolation, and cubic convolution. After the coordinate transformation, pixels are pointed to new locations. The nearest neighbor algorithm simply assigns to each pixel the value of its nearest neighbor in the new coordinate system. It is the fatest resampling technique and is appropriate for thematic data. Bilinear interpolation and cubic convolution techniques combine a greater number of nearby cells to compute the value of the transformed cell. These two techniques use a weighted averaging method and are only appropriate for continuous data such as elevation or slope.

Examples

Example1 : georeferencing a raster using ArcGIS

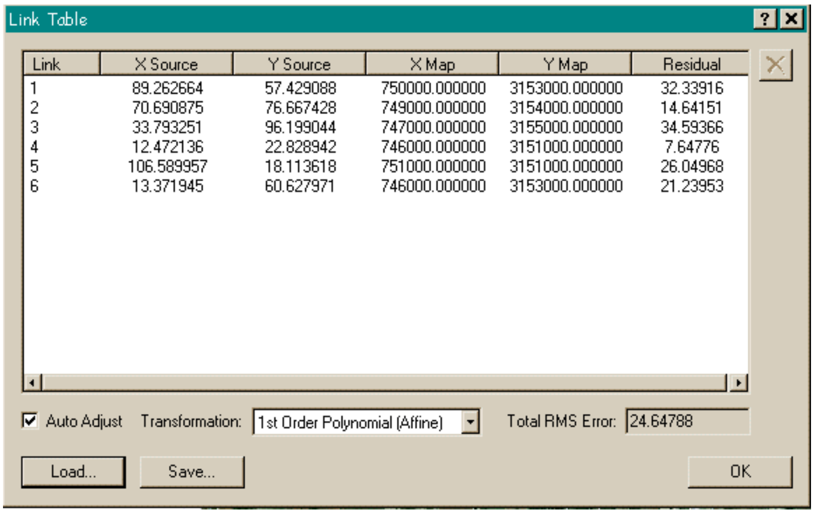
Using ArcGis you can georeference a raster using a polynomial transformation. Image processing packages are more appropriate for accurate rectification. In the example below, the method for georeferencing an aerial photograph is described. A paper map is used to enter explicit map coordinates of control points.



The different steps for georeferencing a raster are :

1. Add to your map the raster you want to warp
2. From the georeferencing toolbar, click the layer dropdown arrow and click the raster layer you want to georeference
3. Click the Control Points tool to add control points
4. To add a point click the mouse pointer over a location which is common between the map and the image

5. Click View Link Table on the georeferencing toolbar



Link	X Source	Y Source	X Map	Y Map	Residual
1	89.262664	57.429088	750000.000000	3153000.000000	32.33916
2	70.690875	76.667428	749000.000000	3154000.000000	14.64151
3	33.793251	96.199044	747000.000000	3155000.000000	34.59366
4	12.472136	22.828942	746000.000000	3151000.000000	7.64776
5	106.589957	18.113618	751000.000000	3151000.000000	26.04968
6	13.371945	60.627971	746000.000000	3153000.000000	21.23953

6. Click a map coordinate and type a new value
7. Add enough points for the transformation
8. Click View Link Table to evaluate the transformation. You can examine
9. residual error for each point and the RMS error.
10. In the Georeferencing menu, choose the Rectify option and select the resampling technique to be used.