

Exercises

9.1 Georeference Orthophoto

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In the following exercises you will georeference a scanned aerial photograph using four different methods:

- an affine transformation,
- a bilinear (2nd order) transformation,
- a tilt displacement correction, and
- a projective transformation *and* a relief displacement correction.

A certain transformation method is usually selected according to the availability of a Digital Elevation Model and distortions to be expected in the image. This exercise however shows the effect of the different georeference methods especially on the accuracy obtained. The geometry of the scanned photograph is transformed to the geometry of another existing map. When the geometries of both match, an orthophoto has been obtained.

9.1.1 Materials

- The digital aerial photograph: ALPAGO
- Digital topographic maps: INFRASTR, DRAINAGE and HOUSE
- A coordinate system: ITALEAST
- A digital contour map: CONTOUR
- A digital elevation map: DEM

You can find these materials in directory C:\ILWIS22\DATA\ALPAGO.

A first look at the files

Before starting the georeferencing process, inspect the contents of the digital files. Find out the domain of the individual maps and the domain of the scanned aerial photograph and check the meaning of the segments in the segment files. Take a close look at the contour map in order to get an impression of the relief (variations) within the area. Calculate the approximate pixel size of the scanned aerial photograph.

9.1.2 An affine transformation

As a first attempt, a georeference tiepoints will be created using an affine transformation. Combine the topographic maps in one map window and display the aerial photograph in another. From the File menu of the map window of the aerial photograph choose *Create, Georeference*. Select Tiepoints. Use coordinate system ITALEAST.

Add ground control points by first clicking locations in the photograph, and then selecting the same position in the digital topographic map. Take at least 10 control points well spread over the entire area.

- What is the minimum number of control points needed for an affine transformation?
- Why should you take more than the minimum number of control points required?
- Perform a check on the accuracy of the transformation by evaluating the residuals DROW, DCOL.
- Can an accuracy check be best performed on the active or on the non-active control points?
- What is the sigma (in meters)?

Display the topographic map on top of the georeferenced photo and make a visual accuracy check. Indicate in which part of the area the distortions are large and in which part they are small. Use the Distance tool.

- How large are the distortions in meters?

9.1.3 A bilinear transformation

As a second attempt, the georeference tiepoints will use a bilinear transformation. In the Georeference Tiepoints editor choose *Edit, Transformation*. Select Second Order Bilinear.

- What is the minimum number of control points needed for a bilinear transformation?

Perform a check on the accuracy of the transformation by evaluating the residuals DROW, DCOL.

- What is the sigma (in meters)?

Display the topographic map on top of the georeferenced photo and make a visual accuracy check. Indicate in which part of the area the distortions are large and in which part they are small. Use the Distance tool.

- How large are the distortions in meters?
- Is there any improvement comparing the results with the affine transformation?

9.1.4 A projective transformation

As a third attempt, the georeference tiepoints will use a projective transformation. In the Georeference Tiepoints editor choose *Edit, Transformation*. Select Projective.

- What is the minimum number of control points needed for a projective transformation?

Perform a check on the accuracy of the transformation by evaluating the residuals DROW, DCOL.

- What is the sigma (in meters)?

Display the topographic map on top of the georeferenced photo and make a visual accuracy check. Indicate in which part of the area the distortions are large and in which part they are small. Use the Distance tool.

- How large are the distortions in meters?
- Is there any improvement comparing the result with the affine and the bilinear transformations?

9.1.5 A projective transformation and relief displacement correction

By creating a georeference Orthophoto and creating an orthophoto, both the nature of the photo (being in a central projection on a plane tilted with respect to the horizontal terrain plane) and the displacement due to relief, will be taken into account. Therefore, information about the photo itself (focal length and the position of the fiducial marks) and altitude information is required.

Entering photo information

From the menu of the map window displaying the aerial photograph, select *File, Create, Georeference*. Select Orthophoto.

For the creation of an orthophoto, the positions of the fiducial marks must be entered. In this exercise the positions of the fiducial marks on the photo are (in mm):

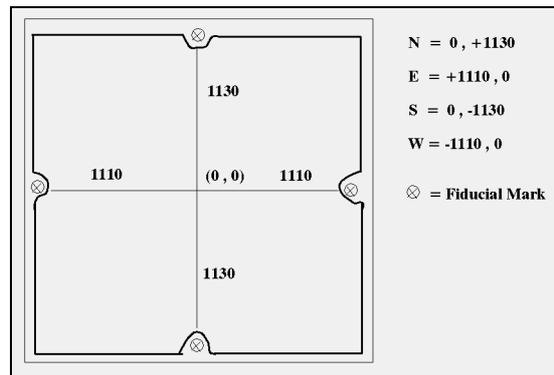
In this exercise the positions of the fiducial marks on the photo are (in mm):

| Fiducial mark | X | Y |
|---------------|--------|--------|
| 1 | -106.0 | -106.0 |
| 2 | -106.0 | 106.0 |
| 3 | 106.0 | 106.0 |
| 4 | 106.0 | -106.0 |

The Principal Distance is 15.2 cm.

If the fiducial marks are not given, they can be obtained from a hardcopy of an aerial photograph. The distance between the four fiducial marks (usually crosses) at the borders or corners of the photo have to be measured with an accuracy of at least

1/10th of a millimeter. Such accuracy is necessary to digitize features on the photograph. The imaginary origin is the center of the photo.
 Example: northern fiducial mark is, say, $x=0$, $y=1130$ (11,30 cm in the photo) and western mark $x=1110$ (11,10 cm), $y=0$.



Entering ground control points

Enter at least 10 ground control points well spread over the entire area. Use only points, which are recognized with certainty.

Accuracy check

Perform a check on the accuracy of the transformation by evaluating the sigma values.

- What is the overall accuracy (in meters)?

Display the topographic map on top of the georeferenced photo and make a visual accuracy check. Indicate in which part of the area the distortions are large and in which part they are small.

- Are there any improvements comparing the results of the affine, the bilinear and the projective transformations?

Display a grid on top of the georeferenced aerial photo; use a grid distance of 500 and choose yellow as display color.

- Explain the shape of the gridlines. In which direction (North, East, South or West) do they converge and why?

Zoom in on a hilly part of the georeferenced aerial photo.

- Explain the shape of one grid line.

In the properties dialog box of the DEM select *Interpolation* and *BiLinear*, click OK and 'refresh' the georeferenced aerial photo (do not enlarge it, but keep it zoomed in).

- Explain the change of shape of the gridline.

Study the *Additional Info* in the properties dialog box of the Georeference Orthophoto and find the flying height and nadir point of the airplane at the moment of exposure.

Open the Pixel Info window and find the height and steepness of a wood covered hill.

Resample the aerial photograph to create an orthophoto (i.e. resample the photograph which uses the georeference orthophoto to the correct North-oriented georeference).