CHAPTER 19

Updating a land use map with oblique air photos

By:

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Summary

In this exercise a series of oblique photos, made in 1991, is available. On one of the photos a clearly new residential area is detected. The land use map of 1978 shows non-urban land use in that area. Transfer of the boundaries of the new site from the photo to the map is done by selecting *tiepoints*, common to the oblique air photo and a topographic map, and then applying a geometric transformation to integrate the new residential area into the land use map.

Getting started

The data for this case study are stored on the ILWIS 2.1 CD-ROM in the directory d:\appguide\chap19. If you have already installed the data on your hard-disk, you should start up ILWIS and change to the subdirectory where the data files for this chapter are stored, c:\ilwis21\data\appguide\chap19. If you did not install the data for this case study yet, please run the ILWIS installation program (see ILWIS Installation Guide).

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- Double-click the ILWIS program icon in the ILWIS program group.
- Change the working drive and the working directory until you are in the directory c:\ilwis21\data\appguide\chap19.

Now you are ready to start the exercises of this case study.

19.1 Available data

Cities in developing countries are (in most cases) growing and changing rapidly. For urban planning and monitoring it is important to have up-to-date land use maps. However, ground surveys to update land use maps are time-consuming, and aerial surveys with "large format mapping cameras" are costly. Recent oblique (bird eye's view) aerial photographs can provide the data to update a map.
Small format cameras are part of a simple and cheap do-it-yourself technique, suited to small areas where no precision mapping is required.

In this exercise a small part of an urban land use map will be updated with the help of an oblique air photo. The urban land use map, a single oblique air photo of the changed area, and a topographic map covering the changed area and its surroundings are needed. It is essential that enough well identifiable common reference points (tiepoints) appear on the air photo and on the topographic map.
The exercise area, named El Buque/El Trapiche, is located in Villavicencio, Colombia.

`Lu78`	Raster map of the urban land uses in 1978.
`Buqmap.gif`	Part of a topographic map scale 1:10000, scanned on a flatbed scanner, annotated with the x- and y-coordinate values, converted to the GIF format, resolution 2458 x 1503 pixels. File size 126,092 bytes (see figure 19.1).
`Pcdimg91.bmp`	Oblique air photo, date 11-04-91, Canon A-1 35 mm camera (image size 36 x 24 mm), scanned with a resolution of 3072 x 2048 pixels, stored as a PCD file on a Kodak Photo CD. The image was slightly cropped, and then saved in the BMP format, resolution 2935 x 1893 pixels. File size 6,292,534 bytes (see figure 19.2).
`Villasec`	Vector map of all building blocks in the city of Villavicencio.

If you compare figures 19.1 and 19.2 you can find out the new development of the city as shown on the oblique photo and locate it in the topomap. The area that is new in the oblique photo is located in the lower centre of the topomap, in the traingle West of the street crossing Calle 15 with Carrera 44 A. Compare the topomap with the image to find out the exact location. Note that the oblique photo has a different orientation than the topomap. It should be rotated 90 degrees.

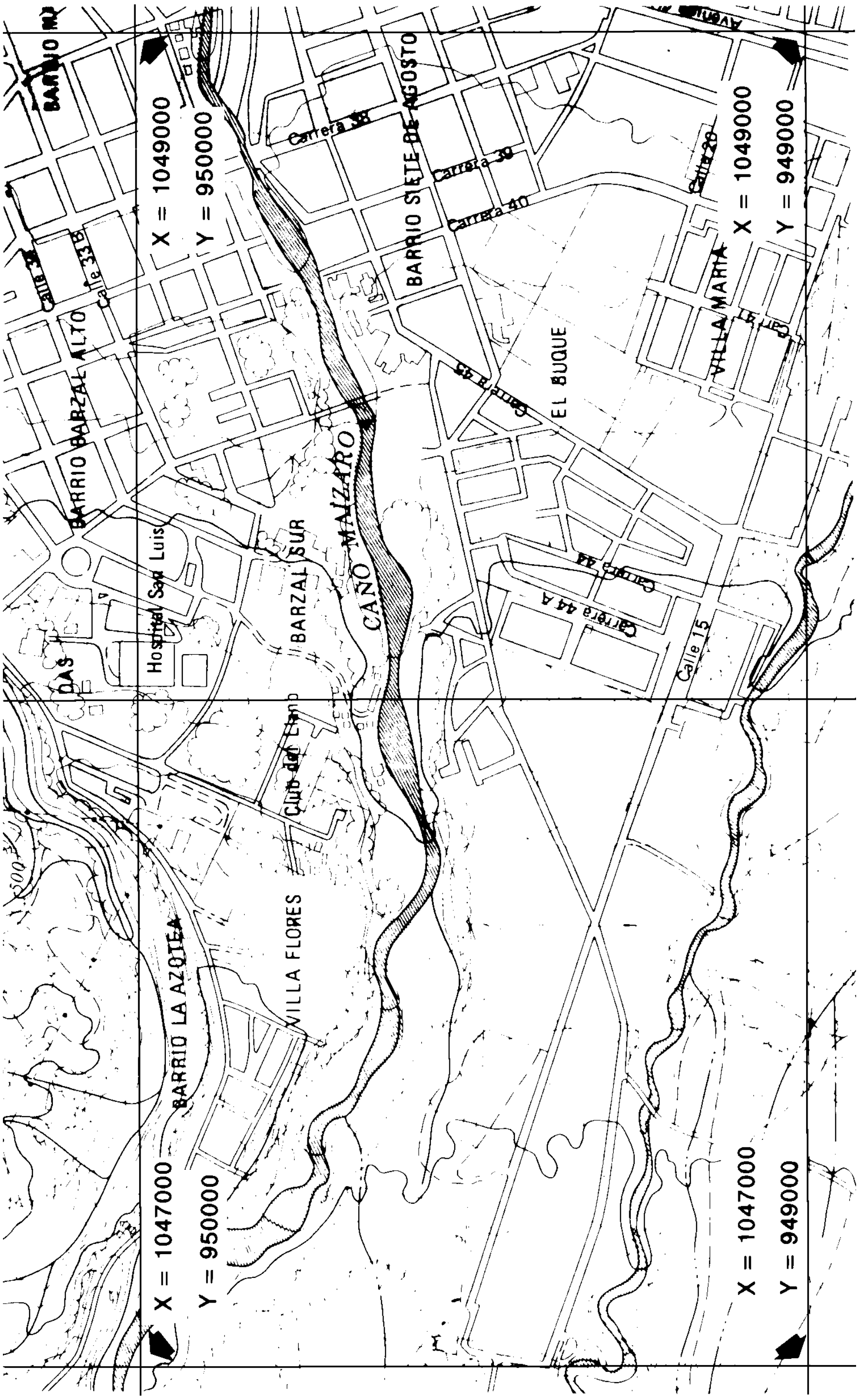

Figure 19.1: Part of a topographic map of Villavicencio, Colombia

Figure 19.2: Oblique air photo of a part of Villavicencio (11-04-91)

19.3 Background information

ILWIS has facilities to select *tiepoints* (common reference points) freely on both photo and map, and geometrically transform photo elements (e.g. the boundaries of the new residential site) to the map projection, and merge them with the map and the database.

In this exercise, an oblique photo of 1991 is linked with tiepoints to a topographic map and geometrically transformed. Information on the photo then can be merged with an existing thematic or topographic map.

Geometric transformations can only be applied on raster maps. The oblique photo is available in digital format as a raster image (map). The transformation method used is the *projective transformation*. This transformation will not correct for relief displacement. The area to be transformed should therefore be relatively flat. Another constraint is that conveniently located and clear reference points, common to both photo and map, may be scarce.Instead of deriving coordinates from a topographical map, it is also feasible to get the coordinates from other sources, e.g. an older aerial photo that has been georeferenced, or from a field survey.

Of particularly interest is the application of precision GPS (satellite geopositioning system), by which the location of clearly visible points on the air photo can be established, without dependency on the selection and generalisation process inherent to map making.

Procedure

1. Convert the oblique air photo `Pcdimg91.bmp` and the topographical map `Buqmap.gif` to (image) maps in the ILWIS format using the option Import.
2. Add a new georeference for the topo map and resample to a new output map.
3. Convert the new topo map to a vector map.
4. Display the building block vector map `Villasec` and overlay the segment topo map to check the transformation.
5. Start the program NewGeoRef and display the oblique photo image map and the georeferenced and resampled topo map. Identify as precisely as possible corresponding points on the oblique photo and on the topo map. These points will serve as tiepoints to link the map with known coordinates with the photo of which the coordinates are not yet known.
6. On the screen click at the location of the tiepoints on the photo and at the same points on the topographical map. Study the tiepoint editor file to deselect points which show too large deviations. If necessary add new tiepoints.
7. Digitise on-screen the new residential area as a polygon.
8. Rasterise the new area polygon and include it in the raster map `Lu78`. Name the output raster map `Lu91`.

19.4 Georeferencing the topo map and the photo image

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- Import the images Pcdimg91.bmp and Buqmap.gif into ILWIS.
- Display the new raster maps Img91 and Buqmap. Zoom in to see image details. Observe that both maps have no coordinates.

With the program NewGeoRef a georeference will be created for the topo raster map Buqmap. The coordinates as annotated on the topo raster map can be assigned to the tiepoints on the map (see also figure 19.1).
The topo raster map will then be resampled to a new output map and converted to a vector map (to superimpose the vector map on a raster map to study the fit). The resample operation resamples the values of a raster map to another georeference, in this way the transformation is applied to obtain a new image in which distortions are corrected and the pixels are square.
Note that the arrows on the topo map (in figure 19.1) are pointing to the crossings of grid lines. These crossings are the tiepoints, of which the coordinates are annotated on the map.

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- Create a georeference (NewGeoRef) called Buqmap; select GeoRef Tiepoints, Coordinate system: Unknown. Give Buqmap as background map. Open the raster map Buqmap. Display Options Raster Map: Buqmap. The image map Buqmap is displayed and the GeoReference Editor is opened.
- Zoom in on the first grid line crossing of which the coordinates are known.
- Move the mouse pointer to this tiepoint location and click. The Add TiePoint window appears. Only the Row and Column values have been filled in X- and Y-coordinates are still unknown. Fill in the X- and Y-coordinate values.
- Continue with the other three grid line crossings.

  Note that the system assigns X- and Y-coordinates for the fourth tiepoint (for an affine transformation 3 points are sufficient to solve the transformation equation). Do not accept these values, but fill in the values annotated on the map.
- In the GeoReference Editor window the *Sigma* is shown. If the sigma is too high (i.e. > 5), one or more tiepoints have not been

defined accurately enough.

- In that case check the DRow and DCol values in the Editor window table and repeat the digitising of the tiepoints with the highest DRow and DCol values. In the column Active make these old values inactive: change the value in the column Active from 1 to 0. Continue when the sigma is acceptable and close the Editor.
- Open the Properties dialog box for the map `Buqmap` and make sure that the georeference `Buqmap` is selected.
- Resample the georeferenced map to apply the now defined transformation, using the command Resample in the Operations-list.
- Name the output map as `Buqmapr` with the georeference `Buqmap`. Resample using the Nearest Neighbour. This resampling is a lengthy process (depending on the computer).
- Break the Dependency link of the new map `Buqmapr`.
- Open the Properties of the map `Buqmapr`. Press the bottom Convert to classes sot that the map is converted from Picture to Class domain.
- Convert the raster map Buqmapr to a vector map `Buqmapr` using Vectorize and Raster to Segment. This also is a lengthy process (depending on the computer).
- Display the new vector map `Buqmapr`.

The vector map Buqmapr will look awfull, with a lot of small segments, and double segments. This is because the Raster to Segment operation is designed to obtain boundaries of units in the vector map with the same meaning. So in fact to obtain polygon boundaries. The topomap only has two units: black and white. Black is used for all lines, names, symbols etc. During the Raster to Segment operation ILWIS will recognize all of these lines, names, and symbols as mapping units, and will try to create boundary lines around them. The segment map Buqmapr cannot be used for generating other maps: too much editing is required. It will only be used to overlay it later on the georeferenced oblique photo.

Georeferencing the oblique photo

With the program NewGeoRef you will also create a georeference for the oblique photo image map `Pcdimg91`.
By displaying the oblique photo image map and the georeferenced and resampled topo map (in vector format) simultaneously on the screen, tiepoints on the photo can be assigned to the coordinates as already known of the same point on the topo raster map by simply clicking these points consecutively.

The oblique photo image map is then resampled to a new output map. Take into consideration the following points:

1. Identify and mark as precisely as possible corresponding points on the aerial oblique photo as well as on the topographical map. These points will serve as tiepoints to link the map (with known coordinates) with the photo of which the coordinates are not yet known.
2. Select tiepoints (control points) common to the photo and the map. Look for points that are clear and well-defined on both, e.g. street crossings, building corners, etc. On the photo consider only the points that are on the ground.
3. The tiepoints should be close to the edges (by preference) and well distributed over the image. A minimum of 4 control points is required for the *projective transformation* which will be applied to the oblique photo. However, preferably a number of extra points should be selected, by editing the tiepoint table the best tiepoints can then be selected for the transformation operation. When a minimum of 4 control points is applied, the calculated deviations are reduced to 0, but this does not mean at all that the transformation is optimal.
4. For realistic results in this case where it is difficult to precisely locate corresponding points, a minimum of 8 points should be active for the transformation.

Before creating the georeference for the oblique photo it is best to rotate the image `Pcdimg91` so that it is oriented similarly as the topomap.

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- First rotate the image `pcdimg91` by 90 degrees using MirrorRotate. Name the output map `Img91`. Break the Dependency link of the map `Img91`. Edit the Properties and change the georeference to `None`.
- Create a georeference (NewGeoRef) called `Img91`, select GeoRef Tiepoints, Coordinate System `Unknown` and the background map `Img91`. Open the raster map `Img91`. The image map `Img91` is displayed and the GeoReference Editor is opened.
- Open the georeferenced and resampled topo map `Buqmapr`. Display it alongside the oblique photo map. Resize both map windows to fit them side-by-side on the screen.
- Zoom in on the location of the first tiepoint on the photo and on the topo map to be able to click the tiepoint location as precisely as possible. Move the mouse pointer to the tiepoint location on the photo map and click.

  The Add TiePoint window appears. Only the Row and Column values have been filled in, X- and Y-coordinates are still unknown.

- Move the mouse pointer to the corresponding tiepoint location on the topo map and click.
  You will now observe that the X- and Y-coordinates become also known (transferred from the map). Click OK and the values are visible in the GeoReference Editor.
- Go to the next pair of tiepoints and repeat the operation until about 8 points have been selected. It may be convenient to first zoom out on both maps, locate the next tiepoint and then zoom in again.
- In the GeoReference Editor go to Edit Transformation and select Projective. Click OK.

Note: a photograph always should be transformed ("rectified") using the Projective Transformation.

- Study the GeoReference Editor table and note the *sigma*. Find the rows with a very high value in the DRow and/or DCol columns. These values are the deviations (measured in image pixels) from the ideal. Have a closer look at these points on the photo and on the map to see what could be the cause of the high values (e.g. not very well defined points or even straight blunders).
- When the values are unacceptable (too high), then change the value True (= active) to False (= non-active) in the column Active by double clicking and typing F. The sigma should decrease when such a tiepoint has been made non-active. If necessary add new tiepoints. When finished, close the Editor.

The georeferenced photo image map might be resampled and displayed to apply the now defined transformation. This resampling is a lengthy process (could be more than 30 minutes depending on the computer). However, this step could be skipped when, as in this case, not the transformed image is of interest, but just the image with attached georeferences (each image point has received coordinates).

The degree of fitting of the georeferenced image map and the vectorized topo map can be studied by superimposing the vector map `Buqmapr` with an appropriate single colour (e.g. red) on the image map `Img91` (display the raster map `Img91` and add the vector map `Buqmapr` as a data layer).

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- Open the Properties dialog box of the map `Img91` and make sure that the georeference `Img91` is selected.
- Open the map `Img91` and add the segment map `Buqmapr` to the map window.

- Close the map window.

19.5 On-screen digitising

In the centre of the oblique photo there is a large new residential area. This area is not shown on the land use map 1978, as it did not exist in 1978. By on-screen digitising the area is mapped as a new polygon map, which can be used to update the land use map of 1978.

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- Display the raster map Img91. Move the cursor to the corners of the photo image and note the X- and Y-coordinates. Derive the minimum X- and Y-coordinates for a map in which the photo image will easily fit (e.g. min X,Y: 1047700, 948900, max X,Y: 1048600, 950100).
- While in the map window, from the File menu create a new segment map called Eltrap (El Trapiche is the official name of the new residential area). Use the coordinate system Unknown. Min X, Y: 1047700 and 948900, Max X, Y: 1048600 and 950100. Create a class domain Eltrap, with only one unit: residential boundary.
- Digitize the boundary of the new residential area. Make sure to snap the segments. Check the segments when finished.
- Polygonize the segment map (select File and Polygonize) in the Segment Editor. Create the output polygon map Eltrap, and select the option Domain. Select the domain Landuse (the same domain as used for the landuse map of 1978: lu78).
- Edit the polygons in the polygon map in the Polygon Editor and make sure that the polygon of the new residential area has the class : residential. Close the Polygon Editor.
- Display raster map Img91, add the data layer polygon map Eltrap.
- Check on the display whether the polygon was digitised correctly. Click in the polygon to see whether the class is correct.
- Rasterize the polygon map Eltrap (Georeference Villa) so that it fits on the map Lu78.

It is important to realize that the polygon and raster maps Eltrap contain one small area with a name (Residential) and the rest of the map did not receive a name: it is undefined (Info indicates a ?).

19.6 Updating the land use raster map

The objective of this section is to update the raster map Lu78 by including the new residential area of raster map Eltrap with a MapCalc operation.

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- In MapCalc use the expression:

  `Lu78u=iff(Isundef(Eltrap),Lu78,Eltrap)↵`

  with the domain Landuse.

Note: The function Isundef makes it possible to include undefined values (or class names) in a MapCalc formula. In map Eltrap the only defined value is the the new residential area (Residential).

The map calculation formula states: if a pixel in map Eltrap is undefined, then give that pixel the value of map Lu78, else give it the value of map Eltrap.

As a result the map Lu78 is changed into Residential (probably from non-built-up) only where the New residential area is located, the remaining area remains unchanged on map Lu78.

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- Display the new raster map Lu78u to check whether the new residential area has been correctly included.

References

Hofstee, P. (1984). Small format aerial photography: simple and cheap do-it-yourself technique. *Cities*, 1(3): 243-247.

Ibid. (1990). Low-cost aerial photography and mapping for urban projects. Paper *Symposium on Global and Environmental Monitoring*, ISPRS Commission VII, Victoria, B.C., Canada, *Int. Arch. Photogram. & RS*, 28 (part 7-1): 216-223.