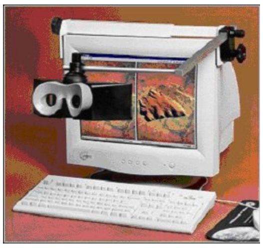
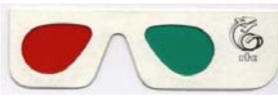
Exercise 2. Creating and interpreting multi-temporal digital stereo images.

Expected time:	2.5 hours
Data:	data from subdirectory:RiskCity exercises/exercise02/data
Objectives:	This exercise shows you how you can generate stereo images from digital aerial photographs and Digital Elevation Models. The stereo images can be displayed using the anaglyph method and are used to interprete the urban development and landslide activity in RickCity from different periods (1977, 1998, 2001 and 2006).





Stereo viewing in ILWIS: A stereo pair allows you to view raster maps, scanned photographs or images in stereo, using a stereoscope mounted onto your monitor or red-green or red-blue glasses (anaglyph). A stereo pair can be calculated:

- with the **Epipolar stereo pair** operation which requires two raster maps with overlap as input, for instance two scanned aerial photographs with overlap; in the output stereo pair you can view the area of overlap in stereo;
- with the **Stereo pair from DTM** operation which a single raster map as input, for instance a scanned photograph or an image, and a Digital Terrain Model (DTM); in the output stereo pair, you can view the whole area of the input map displayed over the DTM in stereo.

A stereo pair is automatically calculated when it is opened for display. The stereo pair then contains:

- two resampled output raster maps,
- where each raster map uses a new georeference which retains original coordinates.

A stereo pair can be displayed:

- in a stereoscope window, while using a stereoscope, and
- as an anaglyph in a map window, while using red-green or red-blue glasses.

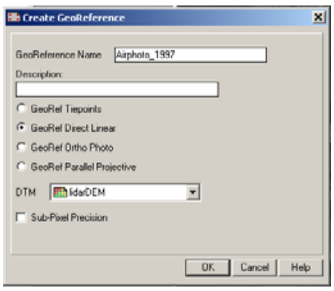
In this exercise we will only generate a stereo image using the option "Stereopair from DTM", since we have a very good DEM (LidarDEM) which includes also the buildings and will allow to give optimal results. Input data:

Name	Type	Meaning
Image data		
Airphoto_1977_original	Raster	Scanned airphoto from 1977 imported into ILWIS
Airphoto_1977_ortho	Raster	Orthorectified airphoto, after generation of a georeference direct linear and resampling to the common georeference of the area.
Airphoto_1977	Stereopair	Stereopair generated from the Airphoto_1977 and the Lidar DEM. It can be visualized using a screen stereoscope or using anaglyphs
Airphoto_1998_ortho	Raster	Orthorectified airphoto from 1998 taken just after the landslide and flood disaster, made after generation of a gereference direct linear and resampling to the common georeference of the area.
Airphoto_1998	Stereopair	Stereopair generated from the Airphoto_1998 and the Lidar DEM. It can be visualized using a screen stereoscope or using anaglyphs
Image_2001_ortho	Raster image	This represents a high resolution colour image derived from an IKONOS image. It has been orthorectified, and resampled to 1 meter. The original colour image was converted to black and white, in order to display it using anaglyphs
Image_2006_Original	Raster image	High resolution image downloaded from Google Earth, which can be georeferenced and resampled in order to use it for the stereo image interpretations.
Altitude data		
LidarDEM	Raster map	This is a Digital Surface Model which has been derived from a laser scanning flight. The original data points have been interpolated into a 1 m raster map.
Landslide data		
Landslide_boundaries	Segment	Landslides in the study area, interpreted from the available images
Landslide_ID	Point map	Points within each of the interpreted landslides with associated attribute table
Landslide_ID	Table	Attribute table with information on the landslides in the area.
Other data		
Building_map_1997	Segment map	Boundary lines of the buildings in the area. Can be used to assess the quality of the orthoimages.

Georefencing an image and making an orthoimage

Note: if you are not interested in learning how to generate an ortho image, you can simply skip this part of the exercise and go to the part dealing with the generation of the stereo images.

Georeference Direct Linear : It is recommended to create a georeference direct linear when you have small format photographs, i.e. photographs taken with normal camera and photographs without fiducial marks, the terrain covered by the photograph has clear height differences, i.e. you need to correct for tilt and relief displacement, a Digital Terrain Model (DTM) of the area is available. By creating a georef direct linear and displaying the photograph, you can for instance directly digitize on the displayed non-rectified photograph on your screen.
A georef direct linear is calculated by a Direct Linear Transformation (DLT):
Row = (aX + bY + cZ + d) / (eX + fY + gZ +1)
Col = (hX + iY + jZ + k) / (eX + fY + gZ +1)
A georef direct linear requires at least 6 tiepoints (also called control points). For each tiepoint, RowCol numbers from the photograph and real world XY-coordinates are stored. Height (Z) values can be supplied by the user, otherwise these are obtained through the XY-coordinates from the DTM. The flying height, the camera projection center (X0, Y0, Z0), the camera axis angles (a, b, g) with the X, Y, Z axes are calculated from the tiepoints.



A georeference defines the relation between rows and columns in a raster map and XY-coordinates. The location of pixels in a raster map is thus defined by a georeference. It is advised that raster maps of the same area use the same georeference. A georeference uses a coordinate system which may contain projection information. Polygon, segment and point maps merely use a coordinate system. A georeference is a service object, usually for several raster maps.

There are five main types of georeferences:

- **georeference corners**: a North-oriented georeference to be used during rasterization of vector data or as the North-oriented georeference to which you want to resample maps;
- **georeference tiepoints**: a non-North-oriented georeference to add coordinates to a satellite image or to a scanned photograph, a scanned map, etc. without using a DTM;
- **georeference direct linear**: to add coordinates to a scanned photograph while using a DTM;
- **georeference orthophoto**: to add coordinates to a scanned aerial photograph while using a DTM and camera parameters;
- **georeference 3D**: to create a three dimensional view of maps.

Normally, the use of orthoimages is the best for the generation of stereo images. An orthophoto is a rectified (North-oriented raster map with square pixels) scanned photogrammetric aerial photograph with corrections for tilt and relief displacement. An orthophoto is obtained by resampling a photograph which has a georef orthophoto to a georef corners. In order to be able to generate an orthoimage specific information on the camera that was used for the airphoto flight is needed. Unfortunately this information is not available in our case. Therefore we will use the other option: georeference Direct Linear.

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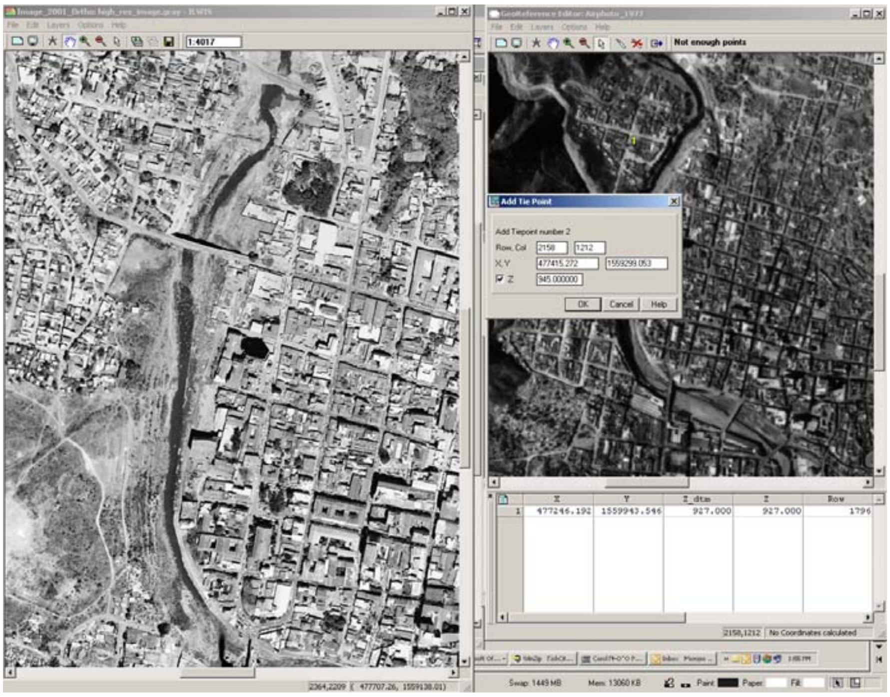
- Open the image Airphoto_1977_original.
- Select *File/Create/Georeference*. Select **Georeference Direct Linear**. Select: *DTM*: **LidarDEM**. *Georeference name*: **Airphoto_1977**.
- The georeference window now opens. Open also the map **Image_2001_ortho**, and arrange the two windows in a similar way as indicated in the figure displayed on the next page.
- Find a similar point in the two images. Zoom in large enough. Select the point in the right image, then select the same point in the left image. Then click the button Z in the Add Tie point window. Click OK
- Repeat this for at least 10 tiepoints. Check whether the sigma is acceptable (should be less than 1 ideally).

Watch Demo 8 for instructions

Tiepoints distribution : It is important to distribute equally the Tiepoints over the image, do not leave empty zones, and fix with the tie points the area near the corner of the image. You can see in the next image to have an idea on how distribute the Tiepoints. In this exercise we will use only 10 tie points but it should be a good habit use about 20 Tie points.



After generating a georeference direct linear with sufficient accuracy, you can then proceed by resampled the airphoto from 1977 to the common georeference used for all the data. This georeference is called “Somewhere”.

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- Select *Operations/Image Processing/Resample*. Select *Raster Map*: **Airphoto_1977_original**. Select *Output raster map*: **Airphoto_1977_rectified** *Georeference name*: **Somewhere**. *Interpolation method*: **nearest neighbour**
- The calculation will take some time. Display the end result and overlay the building map on it to check how good it is.

Creating a stereopair from a DEM.

Stereopair from DTM:
Look angle: The input raster map will be projected twice on the terrain; the input map will be resampled into a left output raster map and a right output raster map. The shift between the left and right output map is determined by the specified look angle. The look angle thus determines the angle by which the left and the right output map are projected over the terrain.
Look modus: You can choose to divide this look angle equally over both output maps (look modus Both), i.e. when the look angle is specified as 30°, the left output map will be projected at 15° left over the terrain, and the right output map at 15° right.
You need to provide a *reference height,* that is the altitude (of the DTM) that should appear at the level of your screen when viewing the stereo pair.
When viewing the stereo pair, larger height values in the DTM will appear 'outside of your monitor', while smaller height values in the DTM will appear 'inside your monitor'.

The Stereo pair from DTM operation creates a stereo pair from a single raster map and a Digital Elevation Model, which can be of the Terrain (DTM) or can be of the surface including the objects (DSM). In our case we are using a DSM: LidarDEM. As input is needed:

- a raster map that you wish to display over the terrain, for instance a scanned aerial photograph, a satellite image, or a 'normal' raster map;
- a Digital Terrain Model (DTM), i.e. a raster map with height values. A DTM is also known as a Digital Elevation Model (DEM).

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- Select *Operations/Image Processing/Stereopair from DTM*. Select *Raster Map*: **Airphoto_1977_ortho**. Select *DTM*: **LidarDEM** *Output stereopaire*: **Photo_1977**. *Accept the default settings.* Click show.
- The calculation will take some time. The end result will first display as dual window. Close this and then select the stereopair **Photo_1977** in the catalog, right click**,** *visualization, as anaglyph*. Use the option: **Red-Blue**.
- Display the end result as Anaglyph and overlay the **building_map_ 1997** by **s**electing *Layers/Add Laye*r and check how good it is. .

Stereo pair: **Photo_1977**

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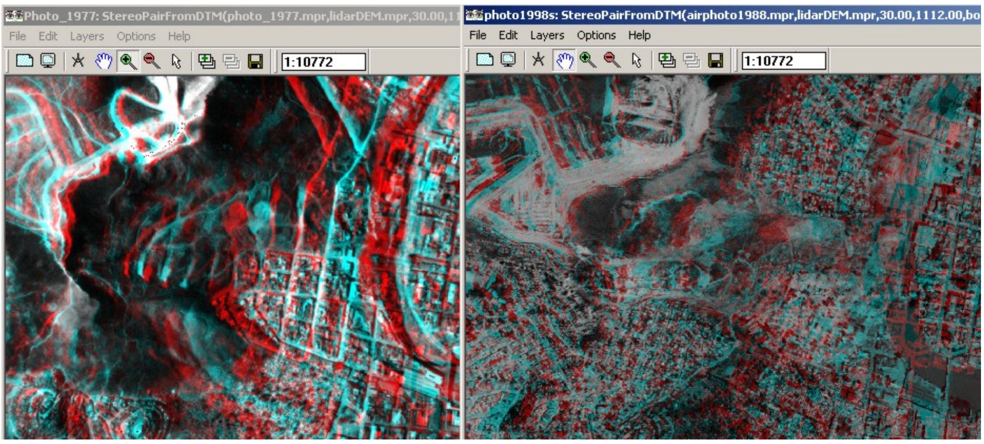
- Repeat this also for the other 3 periods: 1998, 2001 and 2006. Display two anaglyph images of the same area next to eachother (see below) so that you can compare the images well.

After this you have obtained 4 stereopairs for RiskCity: Photo_1977, Photo_1998, Image_2001 and Image_2006. These can now be used in the image interpretation.



Creating a stereopair of a Lidar image.

It is also possible create a stereopair of a lidar image using the lidar itself as a DEM. As image we will use the hillshade of the lidar, then convert in an image and then create a stereopair from it. This procedure will generate a stereopair images where you will be able to easily appreciate the morphologies of the area.

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- Go to *operations, image processing, filter* and select the raster map **LidarDEM**, the filter type **linear** and the filter name **Shadow**. Call the output map **Hillshade_lidar**.
- When you visualize the **Hillshade_lidar**, use the **gray** rappresentation.
- Chose the stretch that you think shows better the object on the area. (we used a stretch between -20 and 20).

Anyway this stretch is only on visualization and so is temporary. It means that if we close the map and we open again we will lose the stretch applied before. In order to have a fix image stretched we need to apply the permanent stretch.

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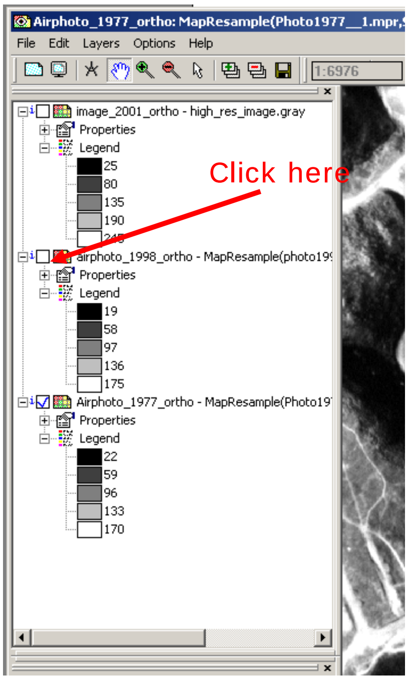
- Go to *operations, image processing, stretch*. Select the raster map **Hillshade_lidar**, the **linear** stretch, and select stretch from -20 to 20, the domain **image**, and call the output **stretch_hillshade_lidar.**
- Show the result map.
- We can now create the stereopair. Go to *Operations, Image processing, Stereo Pair from DTM*. Select the raster map **stretch_hillshade_lidar**, the **lidarDEM** as DTM and call the output **Lidar_stereopair**.
- Show the results and try recognize them.

Comparing datasets from different dates

With ILWIS it is also possible to compare different orthoimages by displaying them in the same map window, and click the display button on and off. We will do this with three images: Airphoto1977_ortho, Airphoto_1998_ortho (taken just after the disaster event) and Image_2001_ortho.



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- Display the image **Airphoto_1977_ortho**. Stretch between 22 and 170.
- Select Layers, Add Layers and select the image **Airphoto_1998_ortho** Stretch it between 19 and 170.
- Select Layers, Add Layers and select the image **Image_2001_ortho** Stretch it between 25 and 245.
- Deselect in the left part of the window the boxes to display the last two images. Now you only see **Airphoto_1977_ortho**. By clicking the box of **Airphoto_1998_ortho** on and off you can compare the same areas in both images.
- You can do the same for **Image_2001_ortho**. This way you can compare two dates quite well.
- You can also add the segment maps **Building_map_1997**, and **Landslide_boundary**

n changes between the three images:

	1977 to 1998	**1998 to 2001**
Main differences in urban areas		
Main differences in morphology		

Mapping from digital stereopairs

Interpeting a digital stereopair:
Since the stereopair has a georeference it is possible to everlay vector information, and use the 3-D information for interpretation. You can directly screendigitize over the 3-D image. This might gie some difficulties in those cases where there is a high difference in elevation. The vector files projected over the terrain do not have an altitude themselves, and appear to be located on the same level. In those cases it is advised to digitize the vector files on top of the ortho image and compare with the stereo image.

The Stereo pairs that were generated in the previous exercise can now be used to interprete the urban development and the landslides in the various images. We will concentrate here only on the 1977 photos, and 1998. The 1977 image gives the best picture of the situation prior to the landslide events, and also since the building density is not so high, allows to best map the old landslides in the area. The photo from 1998 was taken just after the events, and shows the best result for landslide interpretation

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- Open the stereo pair **Airphoto_1977***as anaglyph with Red-Blue colour. Use the anaglyph glasses.*
- Overlay the segment map: **Landslide_boundary**. Now you can compare the landslides that you see in the image with those interpreted in the landslide map.
- Also display the point map **Landslide_ID** , select single symbol, and make them with yellow colours. Each point is related to a landslide component (scarp or body).
- When you double click on a point, the attribute information for that landslide appears. You can now check the activity information, and you can adjust it whenever needed.
- Open also the stereo pair **Airphoto_1998**. Now you can compare the landslides and the flood event for the two periods, and adjust the attribute information
- Discuss the interpretation with your neighbor and outline those landslides where you don't agree on the classification.

Optional: Downloading a high resolution image from Google Earth

Note: if you are not interested in learning how to download an image from Google Earth, or if there is no Internet connection, you can simply skip this part of the exercise and go to the part dealing with the generation of the stereo images.

Hazard and risk assessment should be based on multi-temporal image interpretation and extensive fieldwork. It is important to try to get as many images from different dates as possible. Old images are very useful as they depict the situation which cannot be verified anymore in the field. Also the interpretation of old images allows to identify terrain features like landslides better in many urban area, as there wasn't as much urban expansion as there is today. Also recent imagery is very important as a basis for the field data collection. One important source of information can be Google Earth, which contains high resolution imagery for many parts of the world, including the RiskCity area (Tegucigalpa)

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- Open Google Earth
- If you don't have it installed you might like to try the trial version of the Goolge Earth Pro, which allows to download high resolution images. Go to: http://earth.google.com/intl/en/product_comparison.html
- Navigate to Tugucigalpa/ Honduras
- Zoom in in such as way that the screen covers the same area, as used in the exercises. Make sure to exclude the terrain option and all the text features.
- Before to save the image, make sure that the Navigation command is deselected. Go to *View, show Navigation*, and select *never*.
- Select File / Save/ Save Image (If you use Google Earth Pro select the largest file size). Save the file as Google_earth.jpg
  - Change the extension of the raster image Google_earth.jpg in Google_earth.TIF, or Google_earth.BMP. You can use some software as "paint" for example.
- Exit Goolge.Earth and open ILWIS. Import the file Google_Earth.jpg and convert it to ILWIS format (go to *import, map*, and select the extensions needed)
- You can then use the ILWIS georeference option to make a georeference tiepoints.
- (The procedure is the same of the next exercise, but you start opening the image Google_earth instead of Airphoto_1977_original.

For experienced ILWIS users:

If you have never digitized with ILWIS before it is better not to do this now. There will be another exercise where we will digitize (exercise 4A on the generation of an elements at risk database) which will explain the digitizing procedure in detail.

Vector Data Editing: It is possible to edit the polygon maps, segment maps, and point maps. A polygon map is created by a closed polyline and a label point in it. The point has to be given the attributes of the polygon. Please consult the ILWIS guide for further explanation.

For experienced ILWIS users:

Editing the landslide map and updating it.

- You can improve the landslide inventory map by changing the segment in the file **Landslide_boundary**, and also changing the label points in the point map **Landslide_ID**.
- For the editing of segments, check the ILWIS help first on the most occurring problems. Make sure to connect all lines well. Use Check segments to check the results before proceeding.
- For the editing of the point data, make sure that each landslide part will have a unique ID. For new landslides you will have to add new ID's to the domain Landslide_ID, while digitizing new points. Make sure what the last ID value was before making a new one. Also update the information from the attribute table.
- Once you have edited the segment and point files you can generate the polygon file, and later rasterize this.

- Overlay the **landslide_boundary**, and the **landslide_id** on a stereopair. To edit the segment map **Landslide_boundary**, go to *Edit, Edit layer* and choose the **Landslide_boundary**.
- Select **Insert Mode** to start to digitize new segments. You can also split existing segments to new ones, and after this "snapping" the new segment at the already existing one.
- Use the **Move Point** button to change the position of the points.
- Use the **Select Mode** button to select the object (segments or points).
- Click on the **Exit Editor** button when you finish.

After having digitized the segments, you have to label them by creating label points. Digitize this label point somewhere in the middle of each segment.

It is very important that the polygons described by this segments, must to be closed.

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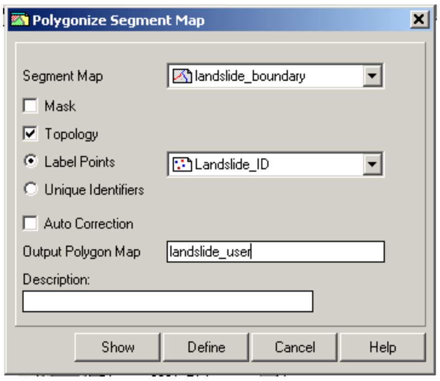
- To edit a point map, go to: *Edit, Edit layer* and select the **landslide_id** map. Use the same buttons as to be used for the editing of segments. After you insert a new point you have to type the new id. A window will automatically open. Select in this window the attributes of the landslide represented by the point just entered.

Before polygonizing a segment map with the label point, it is of extreme importance to check all segments first for errors. You have to remove in a careful – and sometimes time consuming way ! all the errors of the segments.



There are 4 types of errors possible digitizing a segment map:

Dead end in segment: The segment is not connected ("snapped") to another segment.

Intersection without node: The segment overlays another segment without a node.

The same segment is digitized twice : This may happen in large files, or in files you obtain from someone else.

Self Overlap .

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- In the catalog right click on the **landslide_boundary,** end select *edit*. From the menu of the editor, go to *File, check Segment* and select first **Self Overlap**. Correct the errors using the editing button.
- Check also the other kind of error in File, check segment.
- When there are not more errors you can convert the segment map into a polygon map. Right click in the catalog on the **landslide_segment**, *vectorize, segment to polygon*. Call output **Landslide_user**. See the image left.