Landscape study with Historical Photographs through Monoplotting

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WSL MONOPLOTTING TOOL

Short tutorial

Summary

1. Folder structure needed for running the program 3
2. Creating a new project 3
3. Defining the control points 5
4. Camera calibration 6
5. Exporting and saving CPs data as .CSV (*Comma Separated Values*) 9
6. Defining and digitalizing features 10
7. Export 11
8. Importing existing projects 12

Annex I: Iterative procedure for georeferencing oblique non-metric photographs 13

Annex II: short bibliography on the WSL Monoplotting tool 14

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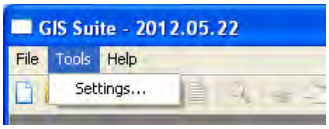
1. Folder structure needed for running the program

- *PIX* → picture related data, incl. pixel coordinates
- *WORLD* → real world related data.
- *.G-SUITE* → project files (*.gis).

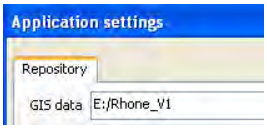
Remark: *please always save the program you used with your data in order to make sure you always can enter and use your data*.

2. Creating a new project

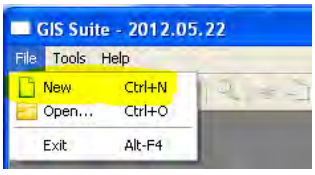
- Defining a folder structure as detailed above: *Tools* → *Settings*:



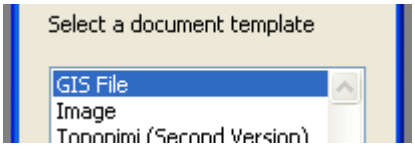
→



- Creating a new project (GIS File):

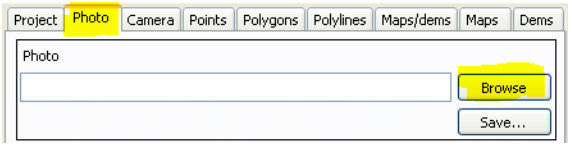


→



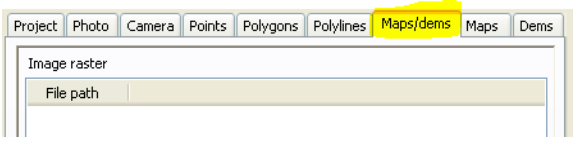
- Upload the three project components: photograph, map or orthophoto and Digital Elevation Model (DEM) (no matter in which sequence):

Terrestrial photograph → *Photo*



Remark: *possibly use a .jpg format, in order to provide the system with the zoom pyramids enabling a quick picture handling*.

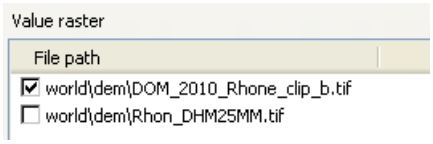
Maps/orthophoto and DEM → *Maps/dems*



Remark: *upload maps in the upper section (*Image raster*), possibly using .tif format. This allows using the zoom pyramids (if present) when manipulating the images*.

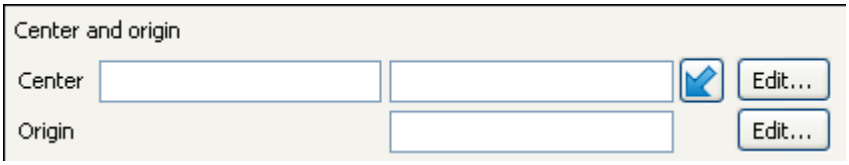
To cover all the area of interest more maps may be uploaded and visualized in the Checkbox.

Upload the DEM in the lower section (*Value raster*).



- Saving the project in the folder *.G-SUITE.*

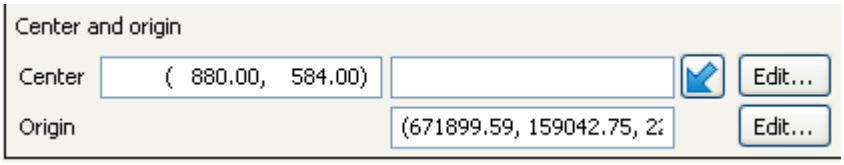
- In the page *Photo* (in the lower part):



Automatically calculate the center of the photograph by clicking  or manually through the edit function (*C* = center of the photograph in pixel).

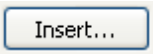
Reconstructing the original camera position at time of photo shooting: function *Edit*…of *Origin*: manually insert the coordinates in the corresponding window or click the supposed shooting point directly on the orthophoto, followed by *Apply*. You do not need a precise estimation; this is just a starting approximation in order to have the shooting direction.

The supposed camera position will be indicated by a red circle  .

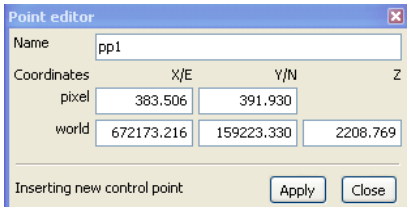


3. Defining the control points

Defining the first 4 control points (CP) allow starting the georeferencing process that on turn helps in defining additional CPs. CPs should be possibly located on a regular surface in order to avoid gullies and small hilltops that are not represented in the DEM (especially when the resolution is slow).

- Open the page Photo.
- Expand the area of interest on the two images (photograph and orthophoto), click 

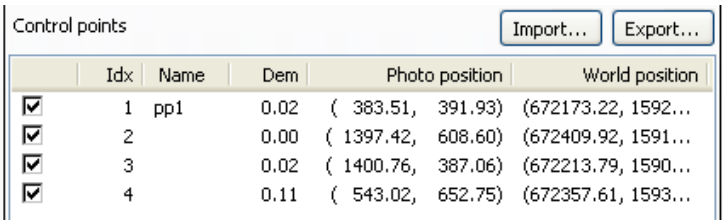
so that the Point Editor will be activated.
- Label the CP.
- Define the point on both images by clicking on the correspondent position. You may keep clicking until you reach the optimal location. Then click *Apply*.



- Repeat the procedure for other CPs (see the Iterative procedure on Annex I).
- If you wish modifying the defined CPs, select them from the *Control Points* list.

  Remark: *when navigating on the map/orthophoto or on the picture, use the mouse and keep the* shift *clicked*.

- TEXT



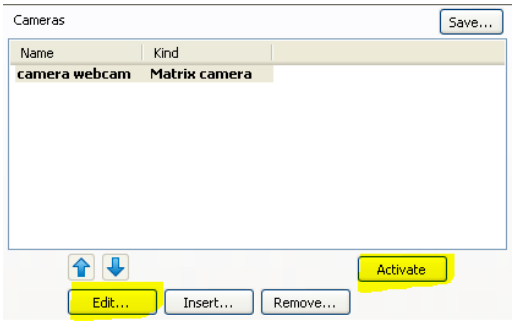
- To eliminate defined CPs, select them and click (

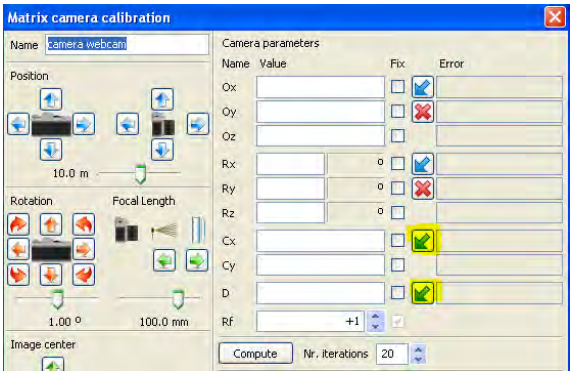
).
- Use Checkbox ☑ for activating the CPs you wish to use for the final camera calibration.

When the desired CPs are inserted, close the *Point editor.*

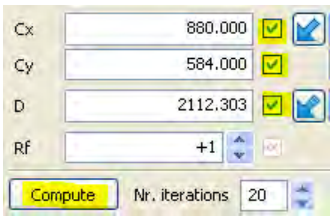
4. Camera calibration

- Page *Camera* → *Insert…* → *Matrix camera.*
- Define a camera name, for instance *webcam* → *Ok.*
- Select the camera → *Activate* → *Copy center from photo data* (importing the center coordinates x e y) → *Edit…*





- Click  of the *Copy center from photo data:* coordinates x e y are automatically imported
- Click  of *Copy focal length from photo data*: the focal distance is automatically imported.
- Directly insert the know parameter in the Checkbox (so defined values are not calculate by the *calibrating* procedure):



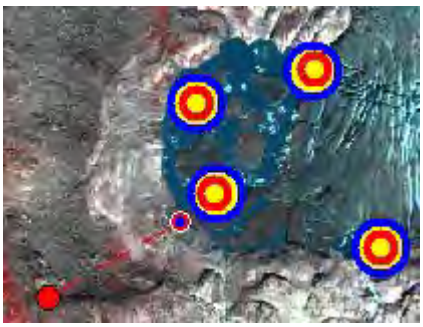
- Click *Compute* (default = 20 iterations): first result is visualized.

  Launching the *Compute* routine enables calibrating the camera on the base of the defined CPs, but independently from the DEM.

- The red dot  on the map/orthophoto shows the calculated location of the shooting camera.

- The blue dot  shows the camera direction. If the resulting direction is completely wrong (180° or opposite), redefine the "Rf" parameter (-1). The relaunching of the calibrating routine is not necessary.

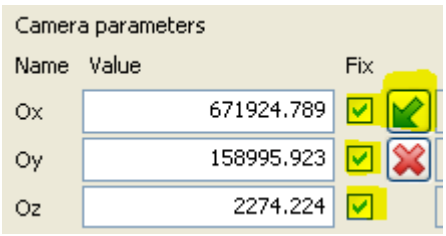
- The CPs are visualized as blue and red circles: in the best cases, the red circle is placed in the yellow filling of the blue circle what means a perfect correspondence of the centers of both circles. Shifts in the position of the paired circles mean an imprecision of the CPs.



- The particular case of a clearly wrong resulting camera position (and correspondingly shifted CPs) may be due to the error optimization around a local minimum detected by the calibrating algorithm. In such case the only solution is inserting estimated initial parameters in order to re-address the algorithm towards the absolute best convergence.

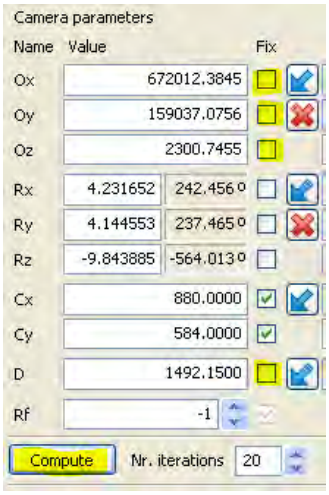
Insert the three camera parameters and initialize them referring to the parameters previously defined in the picture sheets by clicking  .

Due to a limitation in the present version of the program it is presently not possible to insert single parameters in the correspondent fields:



Re-launch the routine (*Compute*) → verify if the camera position improved.

For further improving the calibration, re-launch the routine (*Compute*) without defining the focal distance (*D*) and the camera position (*Ox*, *Oy*, *Oz*):



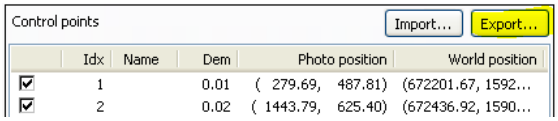
- Parameters for the camera calibration:
  - *Ox*, *Oy*, *Oz*: coordinates of the camera position.
  - *Rx*, *Ry*, *Rz*: Euler angles, not important for the calibration.
  - *Cx*, *Cy*: Image center (pixel coordinates).
  - *D*: multiple of the focal distance (focal distance = D * factor). Speaking about focal distance is not correct because the pictures are scanned and are not in the original format.
  - *Rf*: +1 or -1, according to the correct solution of the calibrating equation.

- Error types:
  - *Pixel*: distance between the CP in pixel as defined on the picture and the corresponding point calculated by the camera on the real world.
  - *Angle*: angle between the line connecting the camera to the CP on the picture and the line connecting the camera with the calculated real coordinates of the correspondent point in the DEM. The best case corresponds to an angle = 0. **Errors below 0.1 may be considered as very good**.
  - *Radius*: distance between the real point and the intersection point of the ray calculated by a plane perpendicular to the ray of the real point. This value is based on the distance of the point.
  - *World (2d):* 2D projection of the error.
  - *World (3d*): real error distance in 3D.

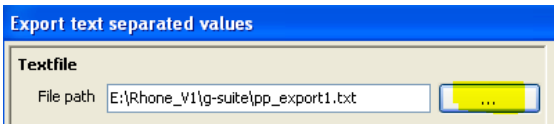
Remark: *the listed errors issue from the camera calibration and not from the DEM accuracy*.

5. Exporting and saving CPs data as .CSV (*Comma Separated Values*)

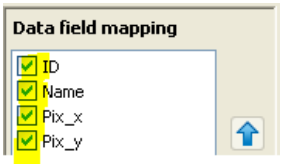
- Page *Photo* → *Export:*



- Choose the path and the filename → *… :*



- Tag in the Checkboxes the informations to be exported:



Remark: *we suggest to export all the data; dropping not useful data can always be done in excel or in another monoplotting project*.

- *Pix_x* e *Pix_y*: represents the picture coordinates:
  - *Pix_y*: number of pixel from the origin in the low-left corner; x and y assume positive numbers when moving to the right and to the top, respectively.
  - *Pix_y_plus*: number of pixel from the origin in the top-left corner; x and y assume positive numbers when moving to the right and to the bottom, respectively.
  - *Pix_y_min*: number of pixel from the origin in the low-left corner: x assumes positive numbers when moving to the right and y assumes positive values when moving to the top, what results in negative values for all y coordinates on the picture!

- Select *Filter* (

) for setting:

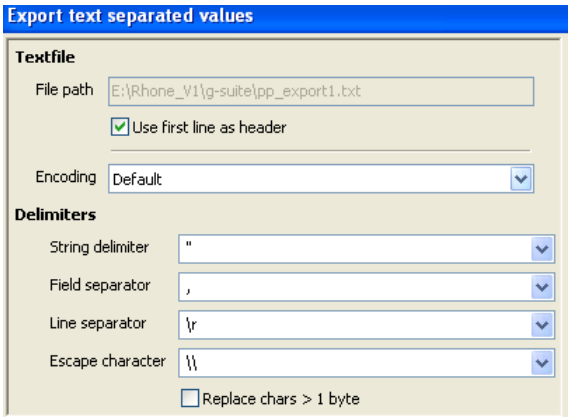
The export of the first row as a header (select *use first line as header*).

Chose *String delimiter* and *Field separator*.

Line separator which can vary according to the OS in use (Windows, Mac-OS...).

Escape character → \\

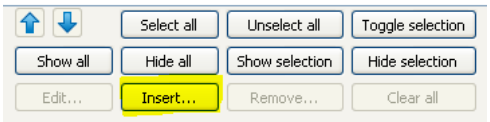
Checkbox Replace chars > 1 byte should be kept inactive.



6. Defining and digitalizing features

- 3 pages for each of the following features: *Points, Polygone, Polylines:*

- Select the correspondent sheet → *Insert:*



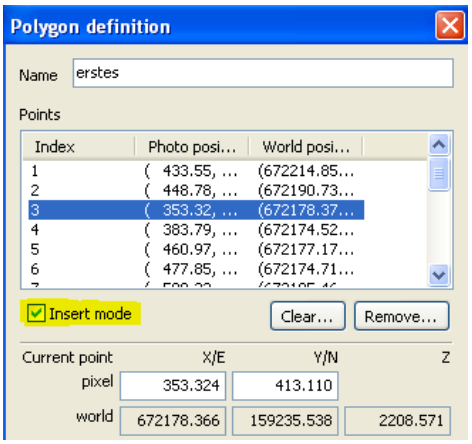
- Label the feature and then insert the correspondent point by clicking on the picture →*Apply* for defining the final shape of the selected feature. The feature name will appear on the list. You may modify the defined feature by selecting it and activating the command → *Edit.*

- Additional points on a polygon or polyline: for inserting additional points in an existing feature, open the point insert window by double clicking the concerned feature in the list.

  Activate *Insert mode.*

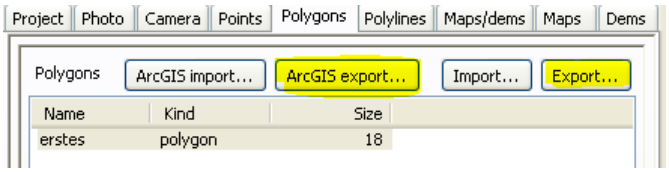
  By default the added point will be listed at the end.

  If you wish inserting the point elsewhere, just select the point where you wish inserting the new point. The point will be inserted just after the selected point



7. Export

- One or more features at time may be selected and exported in .txt format.



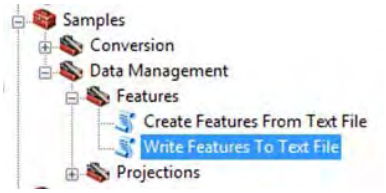
- *Export…:* see Chapter 5.

- Two special commands exist for exchanging data with ESRI ArcGIS™:

  ArcGIS export → insert the file name, and press ok to generate the file. You may import this file in ESRI ArcGIS™ using the Tool *Create Features from Text File.*

  ArcGIS import → similarly you may import a txt file .txt created in ESRI ArcGIS™ using the Tool *Write Features to Text File*.

  The Tools *Create Features from Text File* and *Write Features to Text File* do not exist in ArcGIS 10. They should be downloaded from the ERSI website in advance (*Samples Toolbox*).



Remark: *in ESRI ArcGIS™, due to the coincidence with the final point, the first one is always re-written at the end. In the* WSL Monoplotting Tool *the final point is automatically connected to the first and this is thus not listed a second time at the end of the list*.

8. Importing existing projects

- IMPORTANT: a GIS project (*.gis) can be open only with the program version used at time of its creation. So please always save the program you used with your data.
- First step (important): first defining the folder containing all the geographical data.

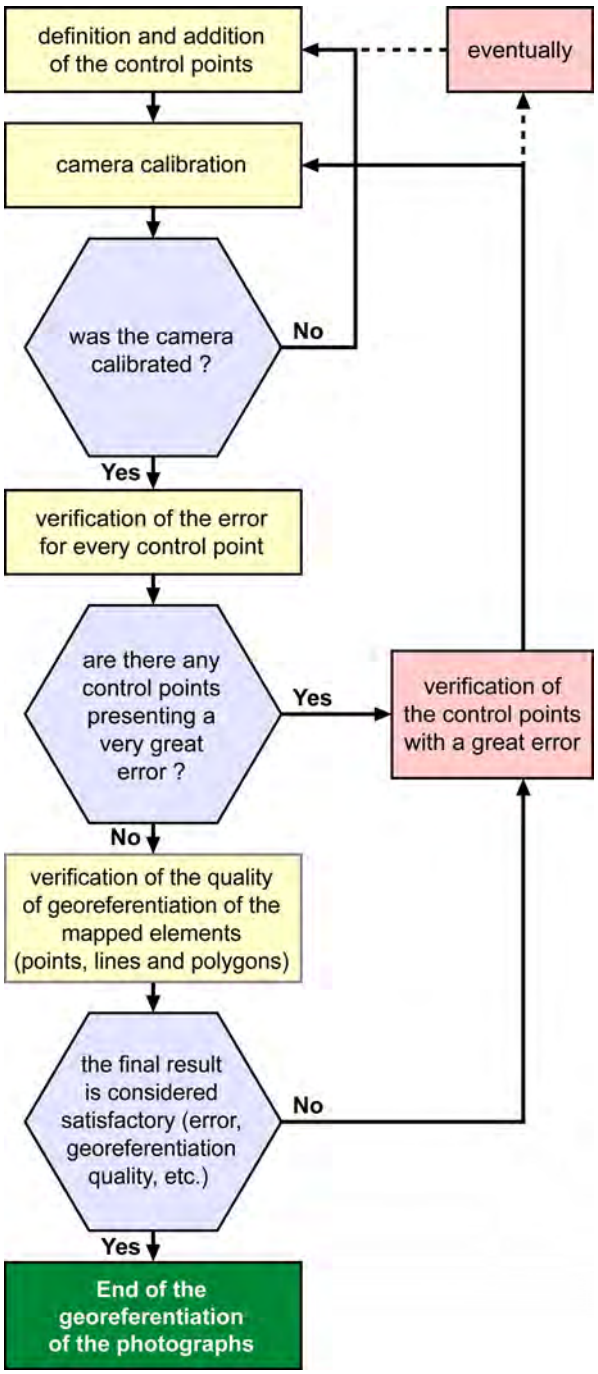
  Tools → *Settings*

  Remark: *if you use old version of the program, please contact us*.

- Open the project (*.gis).
- The file can be also edited using a common text editor if you wish to modify some settings (for instance the file paths). Please pay attention when doing this because you may definitively harm the file making it corrupt and unusable any more.

ANNEX I

Iterative procedure for georeferencing oblique non-metric photographs with the WSL Monoplotting tool



The procedure is based on a quantitative (2D and 3D metric error on the georeferenced oblique photographs) and qualitative (position of the mapped elements, projection of georeferenced elements on the oblique photograph, etc.) assessment of the georeferentiation error and on a repetition of the fundamental operations of definition (and, eventually, re-definition) of the control points and of calibration of the camera.

ANNEX II

Short bibliography on the WSL Monoplotting tool

BOZZINI C, CONEDERA M, KREBS P. 2011. A new tool for obtaining cartographic georeferenced data from single oblique photos. In *Proceedings of the XXIII CIPA Symposium, Prague, Czech Republic, 12/16 September 2011*, Pavelka K. (ed). Czech University: Prague. [http://cipa.icomos.org/fileadmin/template/doc/PRAGUE/025.pdf]

BOZZINI C, CONEDERA M, KREBS P. 2012. A new monoplotting tool to extract georeferenced vector data and orthorectified raster data from oblique non-metric photographs. *International Journal of Heritage in the Digital Era* **1**: 499–518. DOI: 10.1260/2047-4970.1.3.499

CONEDERA M, BOZZINI C, SCAPOZZA C, RÈ L, RYTER U, KREBS P. 2013. Anwendungspotenzial des WSL-Monoplotting-Tools im Naturgefahrenmanagement. *Schweizerische Zeitschrift für Forstwesen* **164**: 173–180. DOI: 10.3188/szf.2013.0173

SCAPOZZA C, LAMBIEL C, BOZZINI C, MARI S, CONEDERA M. 2014. Assessing of the rock glacier kinematics on three different timescales: an example from the Southern Swiss Alps. *Earth Surface Processes and Landforms*. DOI: 10.1002/esp.3599

WIESMANN S, STEINER L, POZZI M, BOZZINI C, HURNI L. 2012. Reconstructing historic glacier states based on terrestrial oblique photograph. In *AutoCarto 2012. Proceedings of the International Symposium on Automated Cartography, Columbus, Ohio, USA, 16/18 September 2012*, Battersby SE. (ed.). Cartography and Geographic Information Society. [http://www.cartogis.org/docs/proceedings/2012/Wiesmann_etal_AutoCarto2012.pdf]