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Fast and automated image rectification with a small (free) software

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Combining and comparing data from different sources or different time period, searching for possible changes in the feature or in the whole landscape under study, is nowadays considered mandatory, thanks to the evolution of the archaeological discipline. This data integration implies also that the sources share the geographical information. If a geo-referencing world file is missing, every raster needs to be rectified and warped, usually through a time consuming manual operation.

AutoGR-Toolkit – a software produced at the Laboratory of Geophysical-Satellite Remote Sensing & Archaeo-environment of IMS-FORTH and freely available at http://www.ims.forth.gr/AutoGR – is a set of 4 scripts (GGRAB, AuttoGR-Sift, GeoRef Filtering, GeoTiff Converter) inspired by 2 algorithm libraries: ASift and GDAL. The purpose of this software is to assist the user in geo-referencing one image on another according to the specific geographical projection, in an easy, fast and accurate way. No special skills are required and the whole procedure can be completed within a few minutes interval.
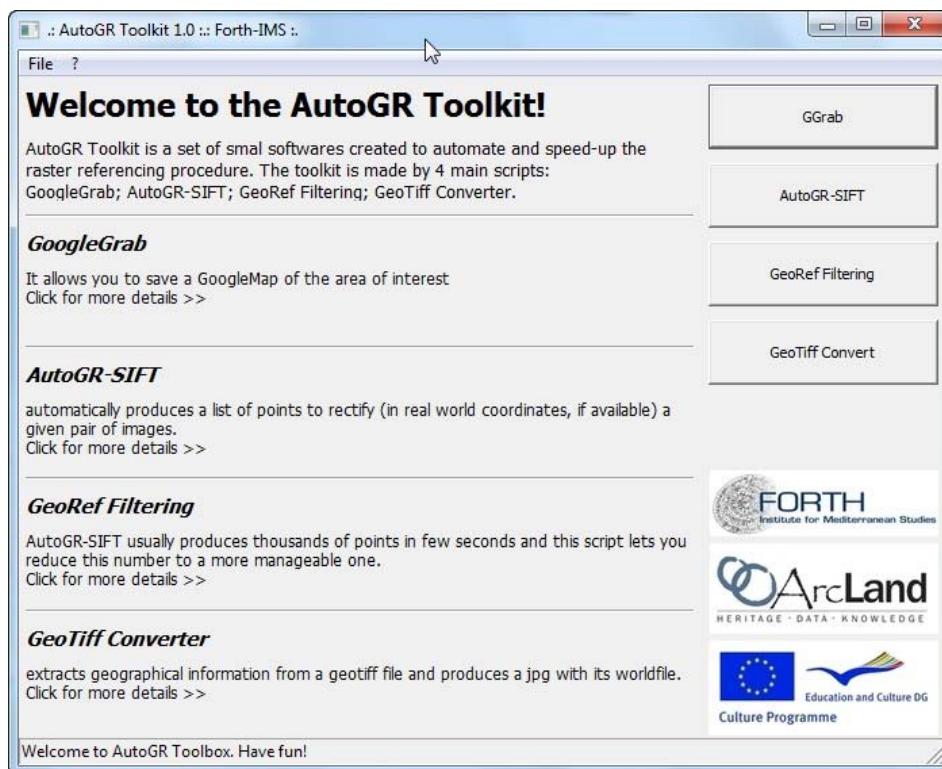
Main menu of AutoGR-Toolkit. In the right panel are the buttons for the 4 embedded scripts:
GGrab; Autogr-SIFT; GeoFiltering; GeoTiff Converter.

With AutoGR-Toolkit, a user can now easily profit of a powerful tool to put in real world position whatever aerial, oblique or satellite image, even starting from a Google screenshot (thanks to the GGrab tool).

Here are the basic principles and functionalities behind each tool in the application:

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GoogleGrab: allows you to save a GoogleMap of the area of interest (for personal use only!) by specifying its North-West and South-East coordinates in the international WGS84 projection system. The user may also specify a different scale (affecting the final pixel size and image resolution) and name for the output image. The script will query the Google server, through the Gdal Library, for the specific area and download a raster of the area with a world file.

AutoGR-SIFT: it is the core and the most interesting part of the Toolkit. This script "prepares" two input images (essentially by scaling and saving a copy of them in PNG format) to be processed by the SIFT algorithm (Scale-invariant feature transform, introduced for the first time by David Lowe in 1999 [1] and now sided by several variants; for the SIFT patent, visit http://www.google.com/patents?id=clcSAAAAEBAJ) which converts the output for a GIS environment.
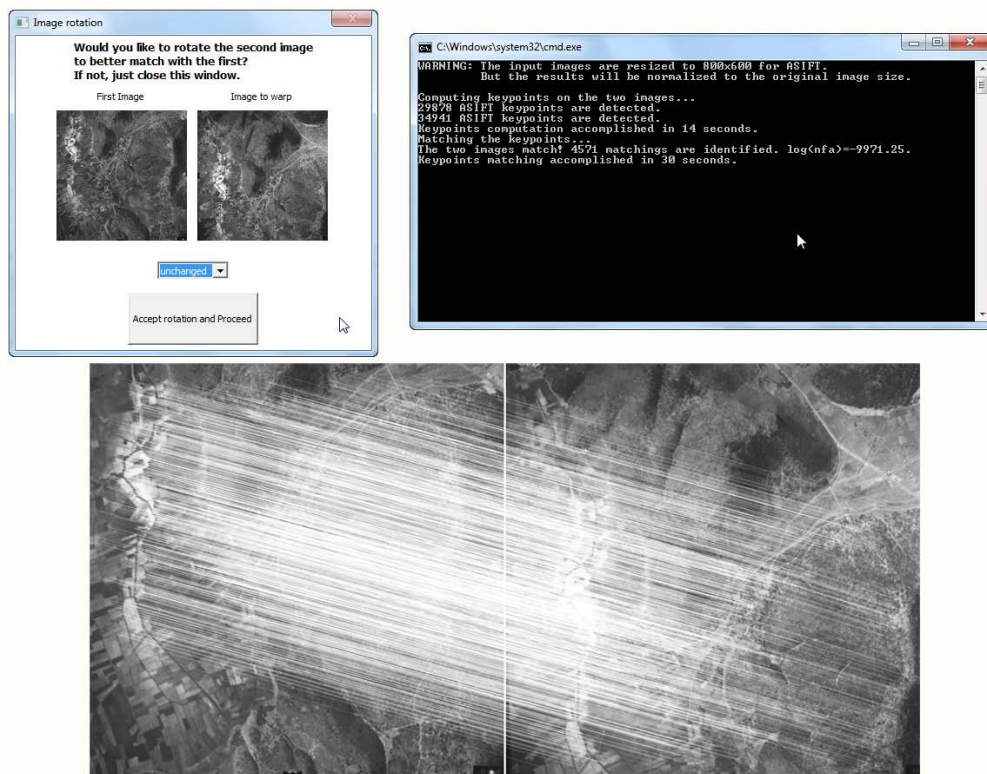
Three different steps of the AutoGR-ASift processing: in the first (top left) the user is asked to check the reciprocal rotation (unchanged, 90,180 or 270 degrees) of the 2 selected images to best fit each other. In the second step, the ASift algorithm searches and compares keypoints (4571 have been found in this specific case). In the lower part, a print of the two images with common points connected with white vectors.

ASift (an improvement of Lowe's SIFT by Yu and Morel's) extracts key points [2, 3] from two images (in PNG, JPG or TIFF/GeoTIFF format) to provide a "feature description" of the object depicted in each of them. Such descriptions can then be used to locate the same object in both images. Once the relation between x and y coordinates of the key points in both images has been found, a structured text file and a visual preview of matching points are created. The common points in XY pixel coordinates are converted into geographical Easting-Northing information by AutoGR without any user interaction.

An automated rectification of the second image is attempted (with the GDAL library). Default parameters have been set as follow: 10 unit for the average residual and 100 as maximum number of points to be used for processing. If this automated version is not satisfying, the user can still edit the point list in a GIS software and produce another version with different parameters.

We believe that this application represents a huge speed-up in the traditional manual photo positioning and provides a sub-pixel digital accuracy that has no comparison with the traditional "manual work".

GeoRef Filtering: the hundreds of points (usually) produced in few seconds by AutoGR-SIFT often need to be decimated in order to be processed by most of the GIS applications. Indeed, to load more than 200 matching points into the georeferencing utility of ArcGIS or QGis may result in software crashes due to lack of memory. For this reason the user is provided with the possibility to filter the points to a lower number (still keeping copy of the whole raw data file).
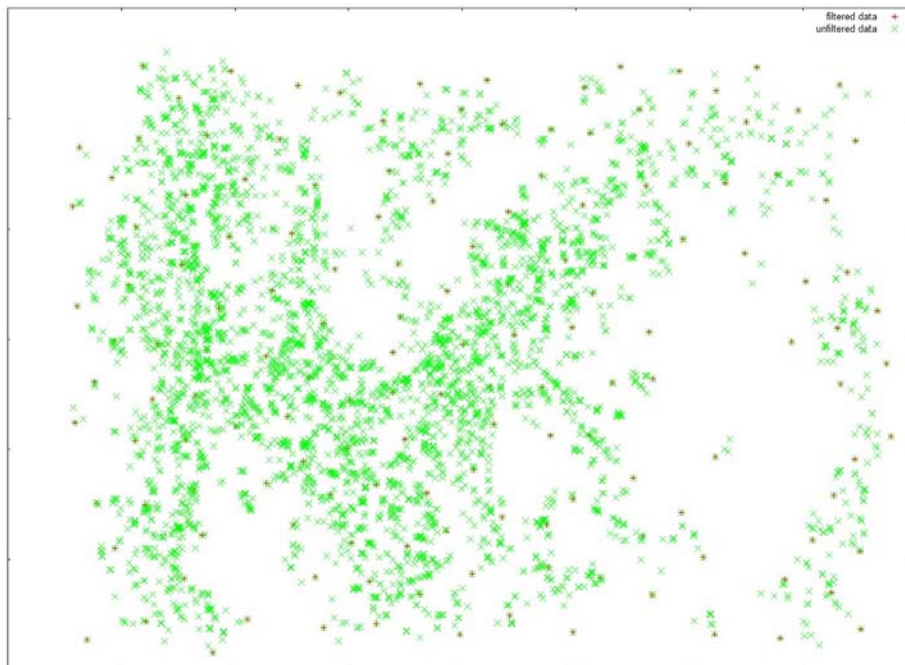
Plot view of keypoints distribution: in green the unfiltered data; in red a selection of 150 points produced with GeoRef Filtering.

The decimation process employs the criteria of maximization of the minimum distance between points, starting from a randomly selected one.

As a general idea, a correct rectification should come from a sub-sample of around 100 or 200 points; the process may be repeated if the result is not satisfactory.

GeoTiff Converter: It is a simple tool to extract the geographical information from any GeoTiff file and save it into a world file via the GDAL library. The selected input geotiff file will be converted in a regular tiff and jpg file (with world files for both) to be used for another georectification with AutoGR-Toolkit or any other GIS tool.

AutoGR-Toolkit and its embedded tools are distributed for free and can be redistributed free of charge.

The automated installation procedure does not require any special IT skills and it does not require either any special hardware or software configuration (even though a good amount of RAM, a multi processor system and a good graphic-card may obviously make the difference in processing time).

Two basic improvement are currently in an evaluation stage: to build and distribute a linux version and to substitute the ASift with another algorithm (just to mention the most important alternatives: ANN; FLANN; I-Asift; OpenCV; OpenSurf; Sift Open Source; SiftGPU; Sift++). Also an iterative folder content processing may be introduced, to speed up even more the entire procedure. The particular research was implemented under the Culture 2007-2013 Archaeolandscapes Europe project (http://www.archaeolandscapes.eu/).

References
[1] Lowe, D.G. (1999). Object recognition from local scale-invariant features, in *Proceedings of the Seventh IEEE International Conference on Computer Vision*, vol. 2; pp.1150-1157.

[2] Lowe, D.G. (2004). Distinctive image features from scale-invariant keypoints, in *International Journal of Computer Vision*, vol. 60 issue 2; pp. 91–110.

[3] Yu G., Morel J.-M. (2011). ASIFT: An Algorithm for Fully Affine Invariant Comparison, in N. Limare (ed), Image Processing On Line.

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