Ludwig Boltzmann Institute
Archaeological Prospection and Virtual Archaeology

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VIENNA UNIVERSITY OF TECHNOLOGY
DEPARTMENT OF GEODESY AND GEOINFORMATION
RESEARCH GROUPS PHOTOGRAMMETRY & REMOTE SENSING

ORIENTAL
Automatic Geo-Referencing and Ortho-Rectification of Archaeological Aerial Photographs

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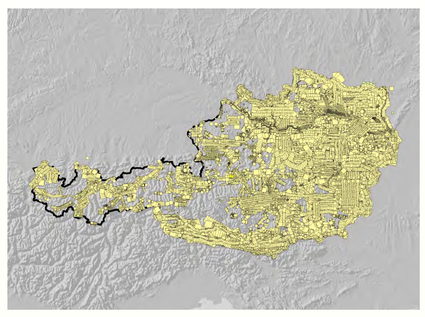
Aerial photography is an efficient method for the **detection of archaeological** and palaeoenvironmental **sites**.

However, photos must be **geo-referenced**, ortho-rectified, and mapped in order to:
- understand **larger** site **structures** and their **layout in the surrounding landscape**,
- allow for **spatio-temporal access and analyses**, and
- **combine** aerial photography **with other prospection methods**.

Imagery taken with sensors for **direct geo-referencing benefits from indirect geo-referencing** concerning **accuracy and redundancy**. For decades, aerial images have been captured without those then unavailable sensors, which leaves indirect geo-referencing as the only alternative. Indirect **geo-referencing**, however, is still a largely manual, **time-consuming** process. Hence, archaeological aerial **image archives** are **crowded with non-geo-referenced photos**, waiting for automated processing.



Approximate footprints of the **110,000** aerial images in the archive of the Dept. for Pre-historic and Medieval Archaeology of the University of Vienna.

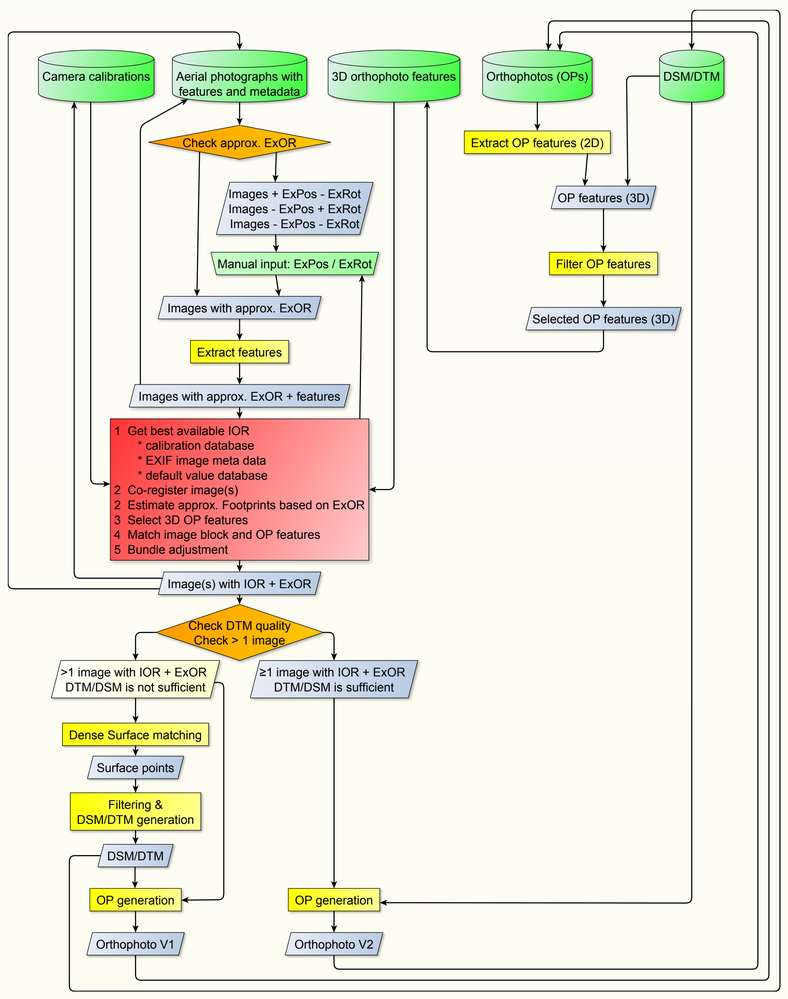
Automated geo-referencing

Starting point: geo-referenced **orthophoto maps** and **digital terrain models** (DTM) are widely **available from external sources.**

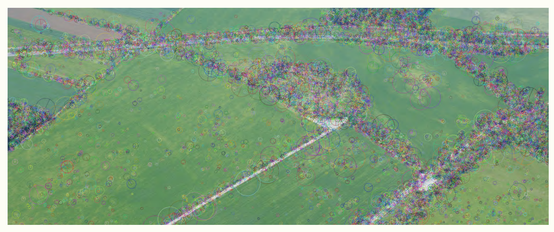
Idea:
- extract 2-D **image features from** external **orthophoto**
- extract their **height from** external **DTM**
- **match** those features **with features** found **in archaeological aerial photos**
- use **meta information** as much as possible to ease the problem (Exif, flight plan)

The figure on the right shows the scheduled processing workflow from archaeological aerial photographs to geo-referenced orthophoto maps.

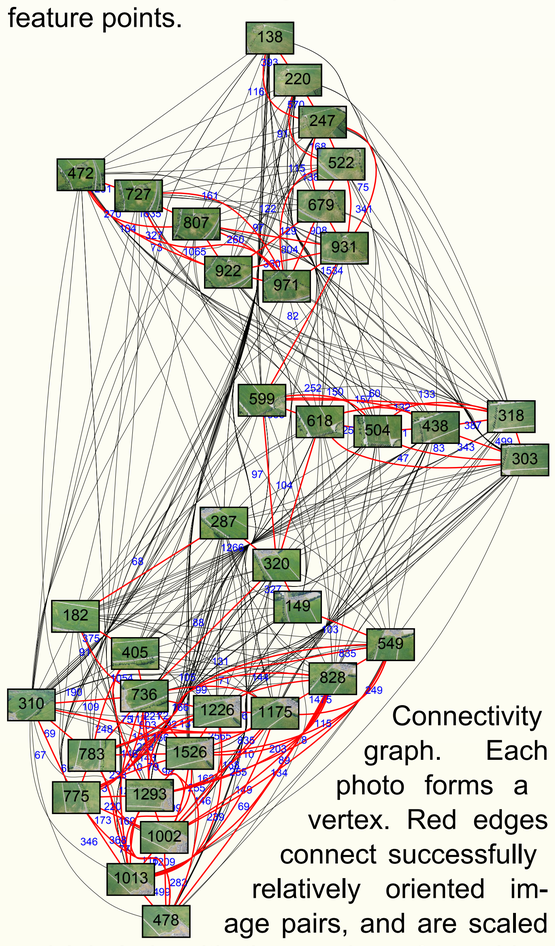
Challenges:
- Archaeological photographers want to **focus on details on the ground**, and **not on fitness for geo-referencing**
- oblique imagery with **completely unknown rotation**
- photos with **random overlap**
- vegetation, and thus **few stable**, and **inhomogeneously distributed image features**
- uncalibrated cameras used with varying focal length



Relative orientation: civil amphitheatre Roman Carnuntum



Oblique aerial photo shot from aircraft side window, with inhomogeneously distributed feature points.



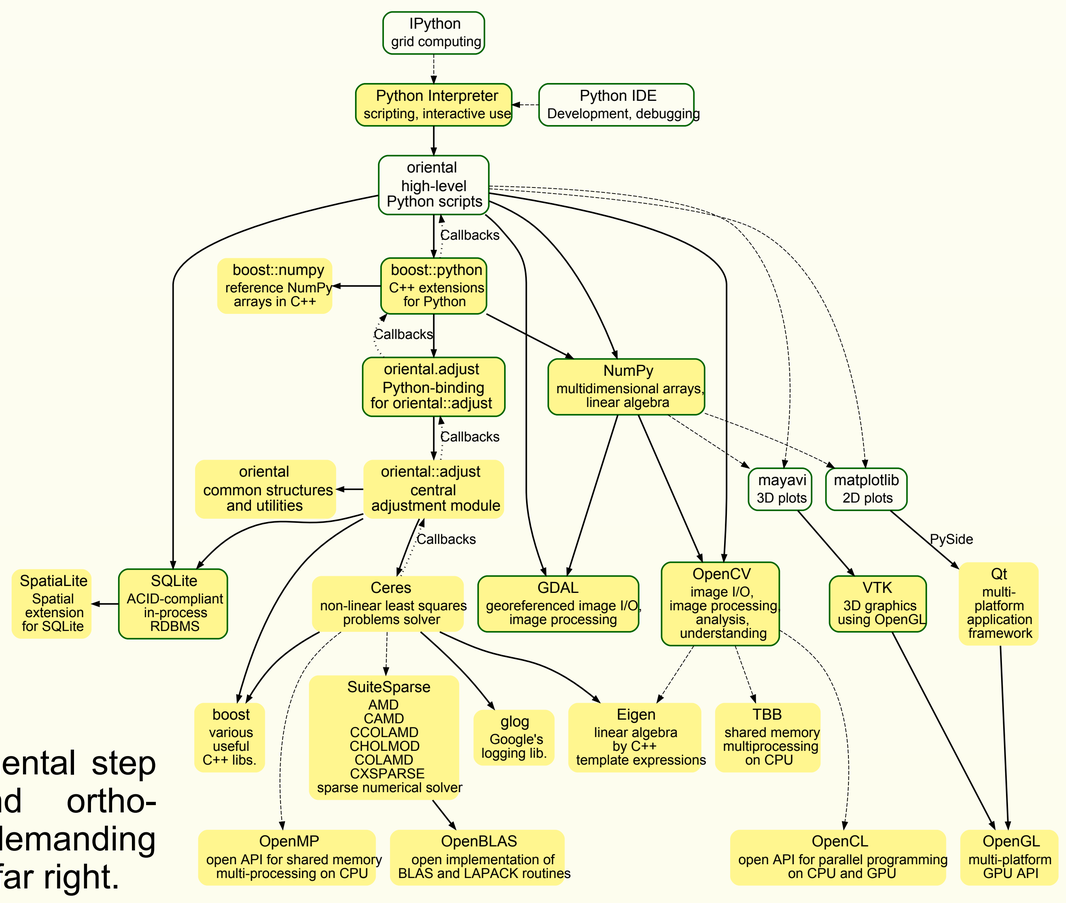
Connectivity graph. Each photo forms a vertex. Red edges connect successfully relatively oriented image pairs, and are scaled and labeled with the number of matching feature points. Lack of overlap results in this sparse structure. Black edges connect photos with matching features in the final reconstruction. Black numbers indicate the final count of observed points in each photo.

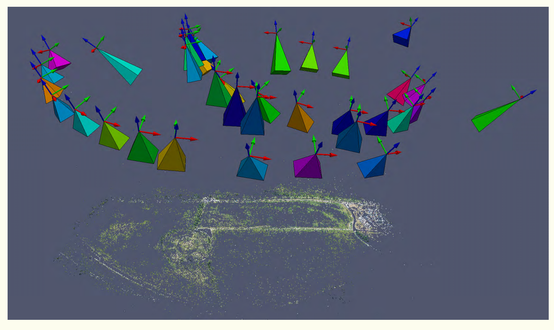
Realization

Photogrammetric framework that
- supports observations beyond image and control point coordinates,
- copes with outliers and
- various observation precisions,
- delivers means for quality assessment e.g. estimated parameter accuracies,
- provides a complete Python interface for assembling custom scripting workflows,
- supports queries and updates of archaeological image archives

ORIENTAL heavily exploits established external libraries and standard interfaces, as can be seen on the right. Modules accessible from Python are framed green.

Based on this framework, and as a fundamental step towards automated geo-referencing and ortho-rectification, the relative orientation of the demanding imagery has been realized, as shown on the far right.





Oriented image block with reconstructed, sparse point cloud.

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