PHOTOGRAMMETRICAL APPLICATIONS TO AERIAL ARCHAEOLOGY AT THE INSTITUTE FOR PREHISTORY OF THE UNIVERSITY OF VIENNA, AUSTRIA

Michael Doneus
Institute for Prehistory, University of Vienna
Franz-Kleingasse 1, A-1190 Wien, Austria
e-mail: michael.doneus@univie.ac.at

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ABSTRACT

The presented paper tries to introduce non-terrestrical applications of photogrammertry within archaeology. Especially aerial archaeology, which is a widely used prospection technique, needs photogrammetry to map the buried remains of archaeologigal sites. At the Institute for Prehistory at the University of Vienna photogrammetry has been becoming an essential part not only of aerial archaeology. Using photogrammetrical hard- and software, vertical and oblique photographs are analized, digital terrain models are measured and digital orthophotos calculated. All these data are used to enhance the understanding of a site´s contexts, reconstruct archaeological landscapes thus bringing the past back to (virtual) life.

KURZFASSUNG

Die vorliegende Arbeit versucht nicht-terrestrische photogrammetrische Anwendungen für die Archäologie vorzustellen. Unter diesen wird die Photogrammetrie vor allem im Rahmen der Luftbildarchäologie, einer weit verbreiteten Prospektionsmethode, benötigt. Dabei werden die Spuren archäologischer Fundstellen dokumentiert und kartiert. Am Institut für Ur- und Frühgeschichte der Universität Wien hat sich die Photogrammetrie zu einem unverzichtbaren Bestandteil (nicht nur) der luftbildarchäologischen Forschung entwickelt. Senkrecht- und Schrägaufnahmen werden mittels photogrammetrischer Hard- und Software ausgewertet, digitale Geländemodelle vermessen und interpoliert sowie digitale Orthophotos berechnet. Die gewonnenen Daten helfen dem Archäologen, Zusammenhänge leichter zu erkennen. Sie ermöglichen außerdem, archäologische Landschaften zu rekonstruieren, visualisieren und animieren, und somit die Vergangenheit zu beleben.

1. INTRODUCTION

The potential of photogrammetrical support to archaeology is quite big. There are several different fields of application covering both aerial and close-range photogrammetry. This paper tries to present both photogrammetrie´s assistance to aerial archaeology and its usage at the institute for prehistory of the University of Vienna.

2. AERIAL ARCHAEOLOGY

It is not only the upstanding remains of our cultural heritage, that is increasingly threatened with destruction. There is an even bigger amount of archaeological sites still hidden in the subsoil. Many of them are in a very bad condition due to intensive agriculture and the exploitation of our resources. Others are already vanished. If they were prior unknown - which comes true of a good deal of these - they are leaving irretreavable holes in the archaeological landscape. To prevent this, the archaeologist tries to detect, document and map archaeological sites, aiming to protect them or at least to extract from them as much information as possible, before they are destroyed.

Among several different prospection techniques, aerial archaeology is a very cheap and productive aid for archaeological survey: Archaeological sites show up on the ground surface, depending on their state of preservation, by light-shadow-contrasts (shadow marks), tonal differences in the soil (soilmarks) or differences in height and colour of the cultivated cereal (cropmarks). In that way, settlements, graveyards, fortifications etc. produce spezific structures, that can be identified easier from a high viewpoint. Especially cropmarks sometimes produce detailled and clear projections of the buried structures (Figure 1).

Both vertical and oblique aerial photographs are used for interpretation. Photogrammetrical analysis of vertical ones is, due to the calibrated cameras, the more or less met normal case and the visual angle, relatively easy, but their motiv is a certain area. Archaeological sites are - if at all - recorded by chance and certainly not from the best angle of view. At oblique photographs, which are made by ourselves, ancient traces are the main motiv. Here, the photographs are taken from the most advantageous position, in order to improve interpretation. Their disadvantage lies in the used "amateur"-cameras, that have sometimes big (and unknown) distortions.

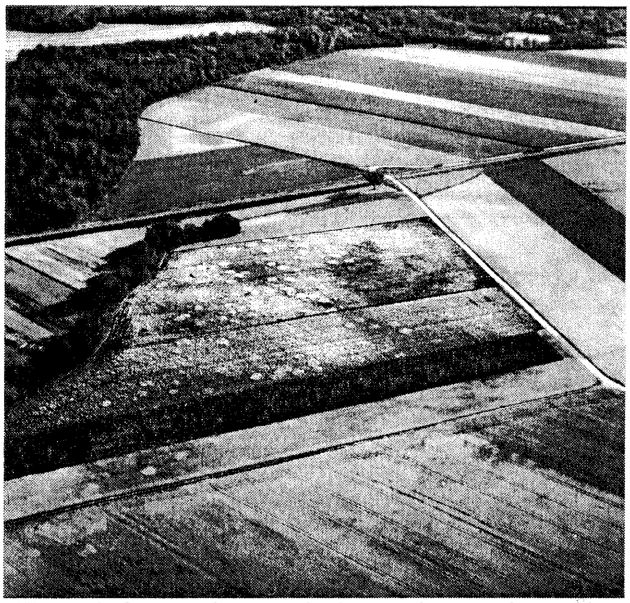

Figure 1: Cropmarks reveal a late antique settlement in Hanfthal, Lower Austria; the light rectangular splodges mark ancient huts (BMLV-Zl.: 13088/011-1.6/94)

2.1 Aerial Archaeology and Photogrammetry

Especially if several flights have been taken within a longer period and at different seasons, more and more details can be drawn from the soil. An important task is hereby to transfer the archaeological information of both the vertical and oblique photographs to composite maps, that are sufficiently accurate and readable for the other archaeologists. Provided with this general view of the archaeological landscape, they are now able to choose their special area of interest for a closer investigation in form of excavations or other, more costly prospection methods (e.g. geophysical prospecting).

Additionally, the description of the topography using contour lines, digital terrain models or profiles of the surface is a clue for a sites interpretation and therefore a prerequisite. It should be done with an accuracy, that is good enough to represent important details of the topography sufficiently.

In most cases, it is furthermore required to combine the results of aerial archaeology with those of other prospection techniques (especially geomagnetics) and to visualize them. Hereby, orthophotos turned out to be a useful device. Apart from this, they have several additional advantages:

- they are objective; interpretations can be overlaid and checked by any other aerial archaeologist
- An orthophoto makes all of the data transparent to the viewer, whereas a vector graphics is an abstraction. With an orthophoto, especially, if it is overlaid with vector data, contexts get clearer and are easier understood
- image enhancement algorithms are applicable
- and finally, it is a prerequisite for any further steps towards pattern recognition and expert systems.

Although the interpretation of the photographs has to be done by trained aerial archaeologists, photogrammetry has to be used to match the requirements posed above.

3. PHOTOGRAMMETRICAL APPLICATIONS TO AERIAL ARCHAEOLOGY AT THE INSTITUTE

To be able to perform aerial archaeology efficiently, the Institute for Prehistory at the University of Vienna is lodging an aerial archive, where both vertical and oblique photographs are stored. Additionally, it began already some decades ago to apply photogrammetrical techniques to aerial archaeology. During this time, a close contact with the Institute for Photogrammetry and Remote Sensing has been established.

Over the years, better standards and a broader range for applications were requested, so that the archive got modern photogrammetrical hard- and software, which is now used in two fields: aerial archaeology and close-range-photogrammetry. The analysis of aerial photographs is done in several steps:

3.1 Basic Analysis

For the basic data, vertical aerial stereopairs are used. Due to a contract with an Austrian military air base we have free access to all of their vertical photographs made by a Zeiss RMK with a format of 23 by 23 cm. Their scales range between 1: 30.000 and 1: 5.000, but a scale of about 1: 8.000 is preferred and mostly available.

Control point information is obtained by geodetical measurements using the Tachymeter TC 1010 (Leica). The analysis of the stereopair is done using an analytical plotter device (DSR 14 by Kern-Wild-Leica) with a PC 386 and the CAD-Software Microstation. Additionally, isolines, surface profiles and both raster coordinates and breaklines for digital terrain models are measured. Due to the fact, that most archaeological sites are covered by one single stereomodel, analysis of verticals is mostly made by stereophotogrammetry without aerotriangulation. The software package SCOP (PC-Version), created by the Institute for Photogrammetry of the Technical University of Vienna together with INPHO, Stuttgart, enables us to interploate our own digital terrain models. Raster data combined with breaklines are both interpolated and create an accurate replica of the terrain. By manipulation of the input data, already excavated features can be embedded.

The basic data, that are provided so far are:

1. the drawings of any feature with a sufficient accuracy
2. 3D data of the topography
3. interpolated contour lines of the terrain and an interpolated digital terrain model (Figure 2)

3.2 Detailled Analysis

In vertical photographs, archaeological sites are - if at all - recorded by chance and certainly not from the best angle of view. Additionally, the flying times are chosen around noon, to prevent too long shadows. Unfortunately, the

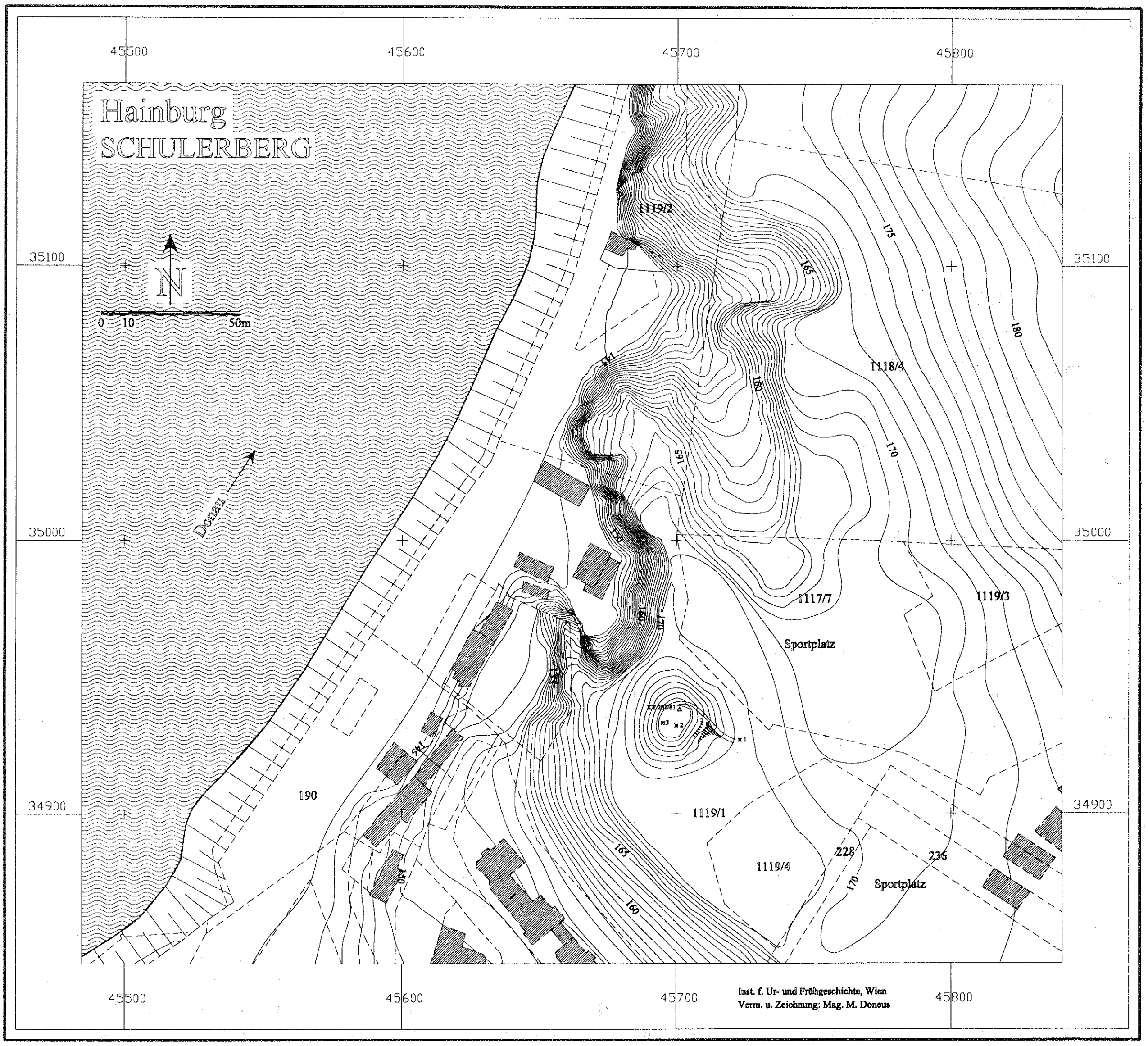

Figure 2: Map of a Hallstatt-Period Tumulus in Hainburg, Lower Austria

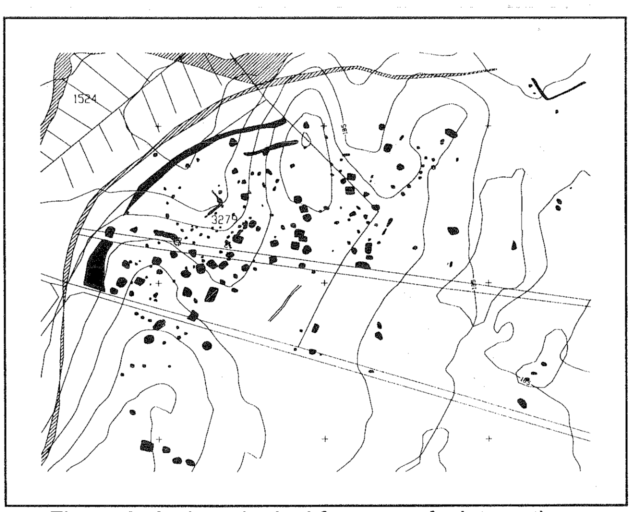

Figure 3: Archaeological features of a late antique settlement in Zwingendorf, Lower Austria; mapped using „monoplotting"

aerial archaeologist very often needs slanting sunlight with long shadows for best interpretation results. That is why additionally oblique photographs are taken, where by choosing the most suitable angle of view even more details of the site can be recorded. Therefore, in most cases, the analysis of vertical photographs alone is not sufficient and oblique photographs have additionally to be mapped.

Restituition of oblique photographs is made by "monoplotting", also provided by SCOP, which is a very advantageous method for us (Figure 3). For this reason, our camera (Hasselblad medium-format; c=60 and 80 mm) was calibrated at the Institute for Photogrammetry and Remote Sensing using the local test-field and the ORIENT software. To get even bettter results, the software-package SCOP was modified for us and contains now also the possibility to correct the distortion of the lense.

Additionally, digital orthophotos are calculated (Figure 4). We usually try to get Orthophotos with a pixelsize between 10 and 25 cm, corresponding to data between 20 and 80 MB. They can be handled by a PC and the pixelsize coincides with that from geomagnetic pictures, which is a reasonable basis for a combination of both. Practically, the photographs are scanned with 600 DPI. The orthophotos are calculated by SCOP on a Pentium 100 with 16 MB RAM and two 700MB Harddisks. The resulting image is outputted on a HP DesignJet 650C, which is a 600 DPI Ink Plotter for A0 paper format. The data are stored on CD Rom, where one CD can hold about 650 MB of data, which is equivalent to two or three projects.

After the application of image enhancment procedures, the interpretation can be checked and improved (Figure 4).

3.3 Combination of Data and Visualization

The combination of the orthophoto and vectorized data as well as the combination of the orthophoto and geomagnetic results is done using Arc Info 7.0. It is running on a Sun Sparcstation with 64 MB RAM within a local network.

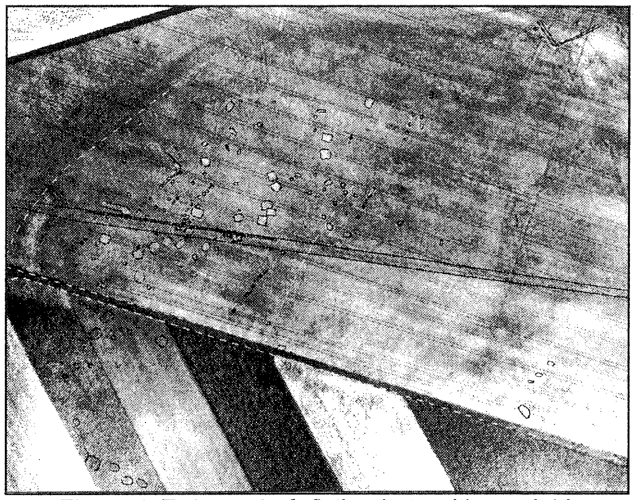

Figure 4: Zwingendorf; Orthophoto with overlaid interpretation (see also Figure 3)

The orthophoto is overlaid with all the other information as the land register, contour lines or interpretations; in the composite image, new details, contributing to a better understanding of the archaeological site, can be seen.

Figure 5: Puch, Lower Austria; Orthophoto with overlaid contour lines and geomagnetics

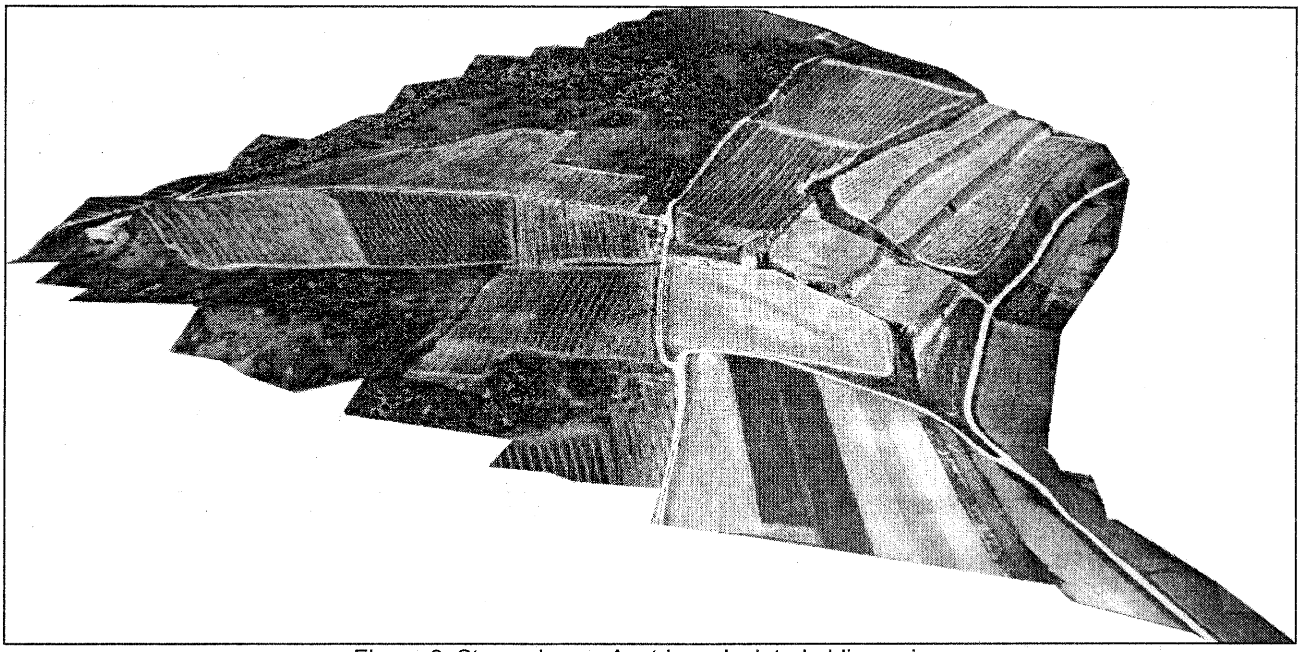

Figure 6: Strass, Lower Austria; calculated oblique view

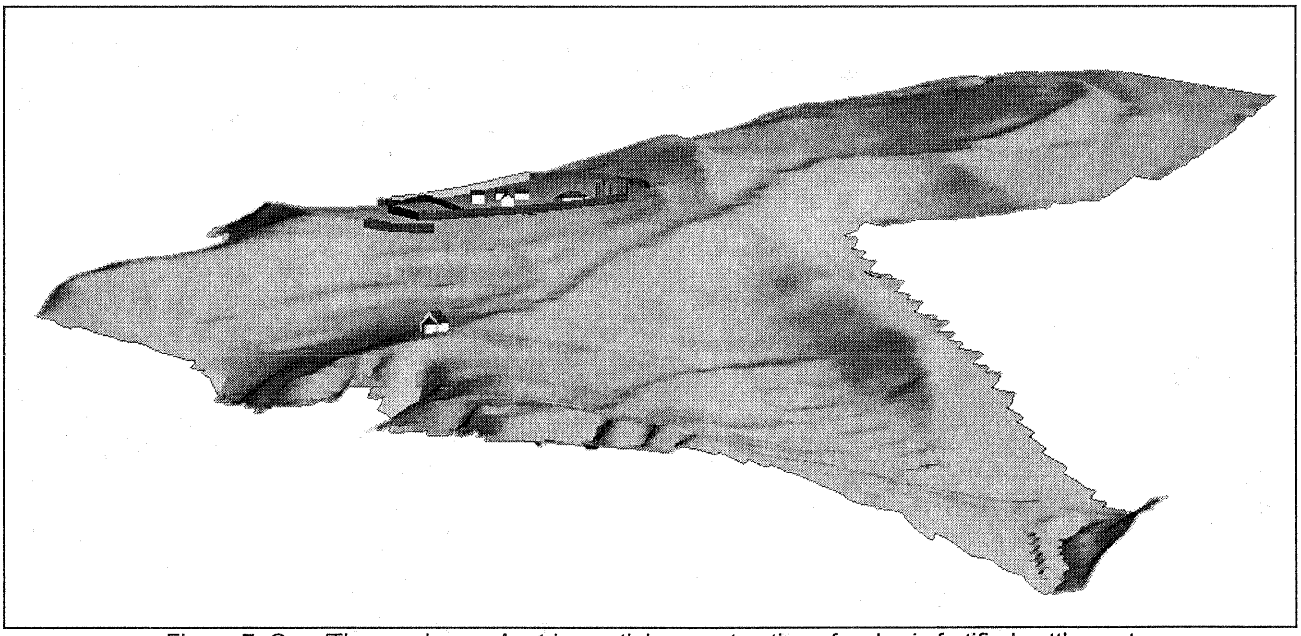

Figure 7: Gars/Thunau, Lower Austria; partial reconstruction of a slawic fortified settlement

When combining the aerial evidence with geophysical prospection techniques, you can give transparency to the geophysics, having the aerial information still visible in the background, and thus giving a good overall-impression of the site (see Figure 5: the double circular ditch system).

The visualization of the site is done in different ways. Very impressive results can be obtained by draping the photograph on top of the digital terrain model. Here, you can give a realistic overview of the site´s landscape, and you can place yourself wherever you want, looking in any direction (Figure 6). In that way, you can also calculate virtual flights and it is even possible to produce stereopairs of your artificial oblique views.

Another possibility is to transfer the terrain data into Autodesk´s 3D-Studio, where they can be combined with 3D-reconstructions of the archaeological features (Figure 7). The result is a realistic image of the site (how it could have looked like) within its terrain. Furthermore, it is quite easy to animate the model.

Finally, the 3D-reconstructions can be integrated into photographs, giving an even more realistic touch to the image. Here, some tests have already been made, and Autodesks 3D-Studio, Rel. 4, turned out to be an adequate tool for this (Figure 8).

Figure 8: Kamegg, Lower Austria; projection of a reconstructed middleneolithic circular ditch system

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