CLOSE RANGE PHOTOGRAMMETRY TO SUPPORT ARCHAEOLOGICAL TRENCH MEASUREMENTS IN TROY

NAHBEREICHSPHOTOGRAMMETRIE ZUR UNTERSTÜTZUNG ARCHÄOLOGISCHER SCHNITTAUFNAHMEN IN TROYA

PHOTOGRAMMETRIE A GAMME RAPPROCHEE POUR SOUTENIR DES MESURES DE FOSSES A TROIE

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Summary

During the excavation campaign in Troy in summer 1991 a close range photogrammetry system was tested with the aim to support the very time consuming mapping work on location. A concept has been conceived which changes the classical mapping method with plumb and metre rule in such way, that due to the use of an easy to handle photogrammetry system the archaeologists themselves perform the measurement works substantially faster in the office and prepare a scale mapping on site without additional measurements.

Zusammenfassung

Bei der Grabungskampagne in Troia im Sommer 1991 wurde ein Nahbereichsphotogrammetrie-System eingesetzt mit dem Ziel, die sehr aufwendigen Kartierungsarbeiten im Gelände zu unterstützen. Es wurde ein Konzept entwickelt, bei dem die klassische Kartierungsmethode mit Senklot und Meterstab so verändert wurde, daß durch den Einsatz eines leicht zu handhabenden Photogrammetrie-Systems die Archäologen selbst die bisher sehr aufwendigen Einmeßarbeiten wesentlich schneller im Büro durchführen und im Gelände ohne Zusatzmessungen eine maßgetreue Kartierung erstellen.

Résumé

Pendant la campagne de excavation à Troie en été 1991 un système de photogrammétrie à gamme rapprochée a été employé avec le but de soutenir les travaux de levé pénibles sur le terrain. Un projet a été conçu, qui change la méthode classique de levé par fil à plomb et mètre de telle façon que, grâce à l'emploi d'un système de photogrammétrie facil à manoeuvrir, les archéologues eux-mêmes exécutent les travaux de mésure, pénibles jusqu'à présent, beaucoup plus vite au bureau et préparent un levé à l'échelle sur le terrain sans mesures additionelles.

Key-words:

archaeological trench mesurements, close range photogrammetrie, excavation, mapping

1. INTRODUCTION

The increasing applications of close range photogrammetry systems for measuring tasks featuring a high amount of points to be surveyed, led to more flexible and easy to handle systems over the past few years.
The advantage of photogrammetry compared to conventional measuring methods consists in a short duration of the measurement on site and in the registration of the object with a high information density on a - for the time being - analogous measuring photograph. As the evaluation in the office depends on the individual requirement of accuracy the time of evaluation can differ strongly.
Originally used in architecture, mainly for the registration of façades, the close range photogrammetry eventually became interesting for the use in archaeological measuring tasks. As a photogrammetrical restitution of e.g. an archaeological excavation profile cannot compete with a classical 'manually' recorded and plotted profile regarding quality and substance of accuracy in detail and optical impression, it is senseless to try and spend additional effort to reach the same level with photogrammetry alone. One rather supports and simplifies the very time-intensive 'manual' measurements of archaeologists by additional implementing photogrammetrical methods.
During the excavation campaign in Troy in summer 1991 this intention was tested and optimized by practical applications. The following report gives a review on the project and wants to indicate an impression of the future possibili-

ties of close range photogrammetry in archaeological applications.

2. ARCHAEOLOGICAL TRENCH MEASUREMENTS

In order to provide an understanding of this report this chapter discusses archaeological trench measurements and the classical procedure how archaeologists execute these measurements.
A large part of the archaeological field work consists in the excavating, uncovering and documenting of areas under the surface of the earth. This very time- and work-intensive duty is usually restricted to certain small areas which are enlarged depending on findings. Often a local surveying network is used for the whole area, which allows to determine the edges of the small area to be excavated by marking the four corners and determining the coordinates. Depending on the size and inclination of this area the coordinate lines of the surveying network are condensed in a 5-10m distance along the area's edges by geodetical measuring methods. The signalization of the 1m grid-lines is usually done by means of measuring tape and plumb. In this way a 1m grid oriented in the local network and which has reference to all mappings is spread above the excavation trench.
Reaching an interesting horizon with important findings during excavation the corresponding 'planum' (scale) has to be mapped. By stretching strings between the markings of the 1m grid next to the excavation trench and by putting out metre rules and measuring tapes (s. fig. 1) all relevant structures and findings are mapped on site. This can be a duty of several hours for areas of few square metres, one of several days for areas of larger extent. Additionally to the planum the four boundary profiles of the trench are mapped in the same way. Here, things are complicated by the fact

that the putting-out of metre rules has to be replaced by mounting them on the profile or, again, by stretching strings.

Fig. 1. putting out metre rules

Fig. 2. measurement frame

In areas with highly inclined horizons the inaccuracy and the effort of putting out the metre rules is too high, so that a 1m·1m frame (s. fig. 2) has to be used additionally. This frame has to be oriented and fitted into the local network. Strings are stretched in a 10cm distance in the frame. Then, by means of a plumb this 10cm grid can be projected onto mapping area. Thus, the mapping can be performed with the required accuracy. Being time intensive this task requires a lot of perseverance and motivation.

3. PHOTORAMMETRY - A DESCRIPTION OF METHOD

By measuring identical points P'_j in the images of a system of images, the images can be oriented relative to one another in a spatial model system of coordinates. The constraint has to be met that the directions of all imaging rays of identical image points of the photographs intersect in the objekt point (s. fig. 3). A system of images encloses all images of an observation period which are defined and evaluated as one block.

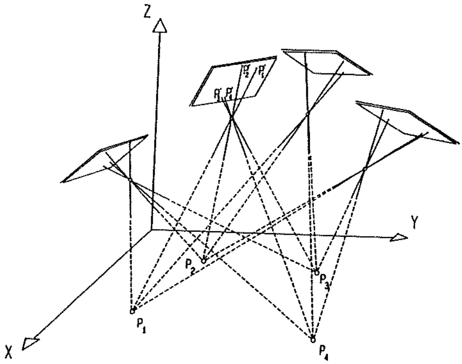

Fig. 3. principle of the multiple image evaluation

By determining the position of the system of coordinates with the aid of three object points and the scale with the aid of two points, a local three-dimensional frame of reference is obtained. All subsequently measured image coordinates can be calculated on the frame of reference.
In close range photogrammetry two methods differing in the evaluation are distinguished, the stereo photogrammetry and the multiple image photogrammetry. In many cases the stereo photogrammetry represents the evaluation method of choice, because a visual and spatial model is used for the measurement. Due to the spatial impression, outlines and profiles can be traced without being formed by discrete points. However, the evaluation equipment is very expensive and requires a regular and professional service. In multiple image photogrammetry the blowup of the photographs are put onto a digitizing table and discrete points in the left and

in the right photograph are digitized by means of a magnifier with crosshairs and are fed into the computer. For measurements of high acurracy this requires that the points in both photographs are easy to identify. Round bodies without a high-contrast texture can only be measured with low accuracy. Compared to stereo photogrammetry the multiple image system has substantial advantages in its flexible handling in recording as well as in evaluation. For recording only modified serial professional cameras are necessary, for evaluation conventional commercial PC's and digitizers.

4. PHOTOGRAMMETRICAL BASIS PLAN FOR ARCHAEOLOGICAL TRENCH MEASUREMENTS

It has been pointed out in the introduction that with justifiable effort the employment of photogrammetry does not lead to results comparable to those of the classical 'manual'-mapping. Still, the use of photogrammetry as an additional aid for archaeological trench measurements can be sensible.

Fig. 4. signalizing of the control point

Confining its use to the photogrammetrical measurement of lines rich in contrast which are easy to measure with a high accuracy, leads to the following procedure:

Before the archaeological registration some circular measurement marks are attached to the profile or planum (s. fig. 4). These marks act as control points which are surveyed geodetically into the local network.

Then the photogrammetrical recording (s. fig. 5) and evaluation take place. The result of the evaluation is a scaled plan which consists of a sufficient amount of outlines of edges rich in contrast (s. fig. 6). 'Sufficient amount' in this case means that later on the archeologists are able to draw the profile or planum only by completion, without any additional measurements with plumb or metre rule. To achieve this, the photogrammetrical plan is put underneath the mapping, thus acting as a basis plan. The archaeologist only draws it up resp. completes it. Doing this the lines of the basis plan are only used as a scale guidance.

Fig. 5. measuring photograph - 'East-Profile D7'

In practical application it became obvious that it may be difficult to get along with the relatively few lines of the basis plan. For this reason the photogrammetrical basis plan contains additional lines in another colour which only show the approximate outlines of objects in the area to be registered (s. fig. 7, the second colour is shown as dashed line). Due to their low contrast these lines can only be measured relative inaccurately, resp. no high accuracy is required for their measurement as they only serve for a better orientation.

Thus, trench mapping may be possible completely without measuring during the mapping. The archaeologist is able to draw the whole profile or planum without interruption due to remeasuring, plumbing, replacing of metre rules, rearranging the frame etc..
In fig. 8. an archaeological mapping of the 'East-Profile D7' is shown.

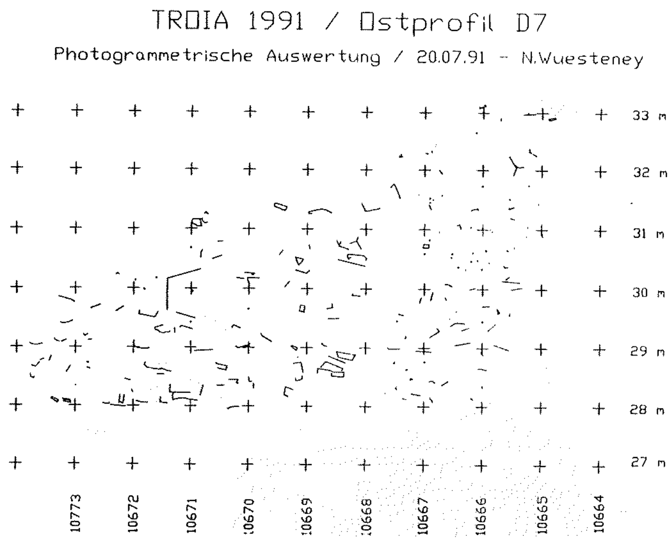

Fig. 6. basis plan - 'East-Profile D7' / only lines rich in contrast

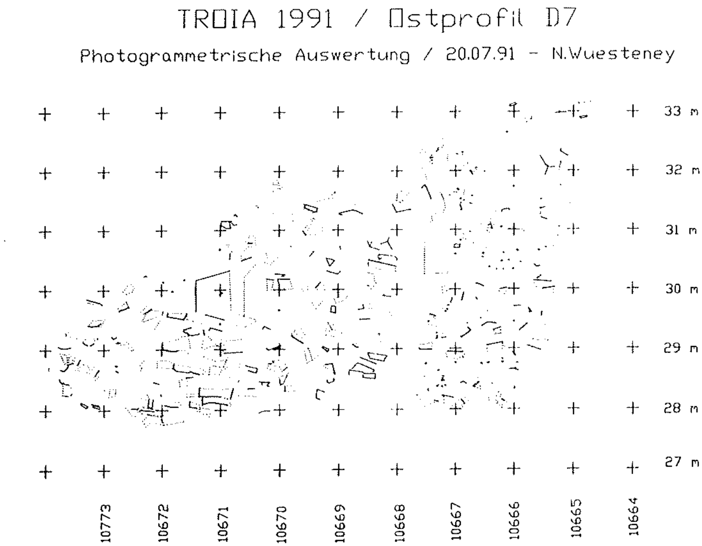

Fig. 7. basis plan - 'East-Profile D7' / with orientation lines

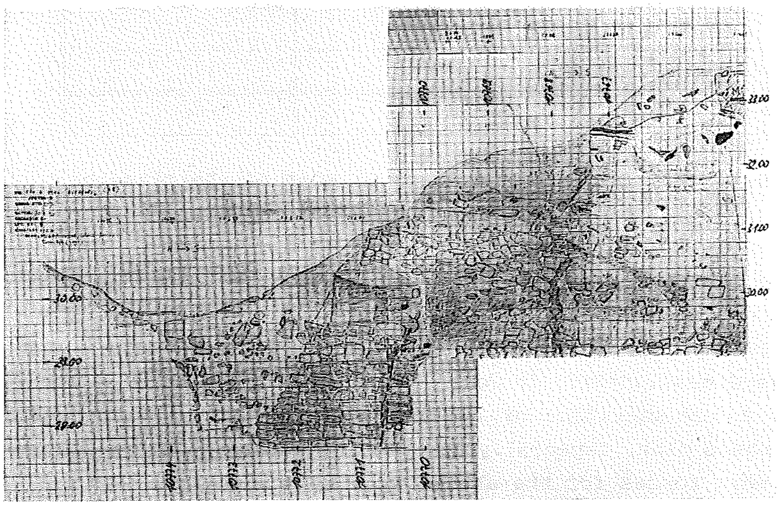

Fig. 8. archaeolgical mapping of the 'East-Profile D7'

The saving of time for the archaeologists depends strongly on the size of the area to be mapped and has to be compared with the time spent on the photogrammetrical elaboration. For areas under approx. 2m² this combined method only pays off in case of a very high information density and a ground rich in relief. Table 1 shows an overview of the first empirical values for profiles with a range of 5-35m². The amount of spend time for the classical method is set to 100%. All the other percentages relate to it. In a realistic example, in which 100% correspond to three work days, 1/2 to 1 work day can be saved.

step of work	classical mapping	photogram. basis plan + mapping
reference	1m grid, putting out metre rules, measuring frame 5 - 20 %	marking points, measuring basis points 5 %
film-, image development	------	3 %
detail measuring	plumbing, measuring distances 45 - 55 %	photogram. basis plan 20 %
mapping	35 - 40 %	35 %
total	100 %	63 %

Table 1. comparison of the steps of work of the classical and the combined method using the photogrammetry

Up to now, measuring of altitudes photogrammetrical methods have not been used for planum mapping. As all coordinates in the photogrammetrical measurement are generally determined three-dimensionally, it would be sensible and possible, with only a low sacrifice of time, to include the altitudes in the basis plan, especially as the classical mapping requires two work forces for the altimetry with a telescope level.
Of course, the saving of time due to the implementation of

photogrammetry has to be compared with the financial expense for photogrammetry and evaluation equipment. Consequently, the employment of photogrammetry only pays when a very frequent use of the equipment can be expected.

Finally, comparing the achievable accuracy, carefulness and experiences in mapping without additional measurement as well as the precision of the photogrammetrical evaluation of approx. 1cm for high-contrast lines are as important as the carefulness and experiences of the archaeologist in setting up the reference points and in measuring details with plumb and rule according to the classical method.
For inclined areas to be mapped, the accuracy of the combined method using photogrammetry and mapping is certainly more stable over the whole area.

5. CONCLUSIONS

During the excavation campaign 1991 in Troy several possibilities of application of the close range photogrammetry have become apparent. Because of the easy handling of the photogrammetry system the use of the method by the archaeologists themselves is planned for 1992. Then it will become clear to what extent the forecast based on the existing knowledge can be confirmed. As a photogrammetrical evaluation by archaeologists regarding the selection of objects is advantageous in any case the acceptance of the method can be expected. The saving of time at the excavation site certainly plays a decisive part, especially in Troy with temperatures around 40°C and strong wind.
Photogrammetry could also be employed in a helpful way in the work in Troy, since a lot of architects have already occupied themselves with the method of photogrammetry itself, especially for façades surveying.