MAPPING EXCAVATIONS AND ARCHAEOLOGICAL SITES USING CLOSE RANGE PHOTOS

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ABSTRACT:

During the last decade there have been many constructions of roads and other technical works taken place in Greece. All those have caused an extraordinary great number of newly found archaeological sites due to all those constructions. In all cases there is an extraordinary need for fast mapping techniques in order to continue the construction works. Usually archaeologists need a long time for excavating the site and after that they need another long period for documenting all the findings with surveys and photos. The real need is to describe and document the status of the findings and in some cases this should take place several times while the excavation continues to the lower levels of the site. We also can have the determination and analysis of the site in order to compare the uses of the site throughout the years. Close range techniques have been developed in order to solve this problem. Another extra we have nowadays is the software development which solves many problems and makes things easier.

Finally some examples are given from applications that took place during the construction of Egnatia which will be a vital main road in north Greece. In those examples we have used a radio controlled model helicopter to take the photos from which we have then produce the final plans and orthophotos.

1. INTRODUCTION

A major need of archaeologists during and after excavations is an accurate and detailed plan of the site for documenting the situation of the findings. This plan in many cases should be drawn in various layers of the excavation due to differences in the lower levels of the site. They should do this for recording the situation of findings, for studying or restoring the sites and programming the future excavations. Registration for a monument is needed each time we want to study, or to repair, or to reconstruct, or to conserve it. There is no possibility to do anything on a monument or an archaeological site without drawing its present accurate situation on a plan. Also in some cases we have to survey the monuments just for registration purposes only, because there are monuments which are invaluable and we have to register them in detailed archives. This becomes more obvious for all classical ancient monuments all over the world. The necessity of surveying the monuments and the archaeological sites is obvious.

Traditionally they survey the excavations using string-grids or in a better case theodolites or total stations. Last years the classic method of surveying by architects is modernized and automated with less people and time needed for similar or sometimes better results. New techniques are developed that give various methods for the survey and the editing of the final plans. Even more when we need detail surveys in large scale we need high accuracy in measuring thus we apply special surveying methods. Whenever a detailed plan is needed in great scale we have to apply different methods in surveying. Last years the classic method of surveying by architects is modernized and automated with less people and time needed for similar or sometimes better results. Apart of all those techniques photogrammetry has also changed a lot and became friendlier in a great number of specialists due to its automation through computers.

When we choose photogrammety, we need high accuracy in control points. Another factor we have to face is that we need very high resolution in shots; therefore we use large format cameras. Usually we use control points for the survey which are permanent marked on its surface in a way that they can easily be used for further densification of the details in future surveys. In this way we succeed to have higher accuracy and connectivity of the measurements between different measuring epochs. At last emphasis has been given in detail surveys as a major tool for studying the monuments. Also detailed plans are used for reconstruction in a computer graphic environment, those presentations are valuable for restoring the monuments.

As a result of the above many scientists are involved in surveying monuments. Their specialization varies widely and a common language is needed but more over is needed their close collaboration. So the archaeologist, the architect, the conservatist, the engineer, the phogrammetrist, the surveyor, and others are requested to work together as a team. And generally, I believe that, we are leaded in a new century of teamwork, because of the huge and very fast development of technology.

On the other hand the cost that concerns both time and money has been eliminated in the modern methods of surveying. This is because of the automation in many steps in both field and office work. Even though the cost of the initial instrumentation is higher it is worthy because you have the payback sooner. Many new techniques have been developed for surveying monuments during the last years. This happened because of the development of instrumentation in surveying, of computers which automated most of the work, of photogrammetric instrumentation from analogue plotters to the digital plotters and

the remarkable acceptance of archaeologists for the new technology.

The new techniques depended upon the size of the monument, the scale of surveying and the required accuracy. Most of the new techniques are based on photogrammetry, even though surveyors have yet the responsibility for target control points establishment. As already mentioned above photogrammetric surveys are depended on the accuracy of control points, which observed with classic surveying methods using total stations or GPS. The density of control points depends upon the scale. The accuracy of the control points depends on the method of their determination and the accuracy of measuring instruments. Another applied classification deals with the type of the used camera, which could be metric, semi-metric or non-metric and also digital camera. The number of required control points depends also on the type of the camera and the method of solution for extracting the final results.

Apart from all of the above we use many types of platforms to take the proper shots, such as kites, balloons, grains, model helicopters etc. in order to carry the camera at the appropriate distance from the object we want to survey (Y. Miyatsuka, 1996). After that we have the choice to manipulate the images in many different ways with several programs in order to obtain the final results. The conclusion is that more easily with fewer hours and less people we can have valuable results, which have much accurate information. Thus for a model helicopter has been developed in order to be used for taking photos from a short range of 50 to 200 m. It can carry a semi metric camera Rolleiflex 6x6 and alternatively a 35mm camera.

2. FOTOGRAMMETRY IN SITES

In addition we have the development of the stereo plotters which lead photogrammetry into the "digital darkroom" (Patias 1991). Today both hardware and software in this section are developed and is subject of changing very often towards better solutions. Using CAD programs we can easily produce 3D plans of the buildings and findings in the excavation as mentioned for city plans (Gruen 1998). This is a powerful tool for architects and archaeologists when they wand to visualize the site (Ito et al 1998). Such 3D drawings can have several applications. But accordingly to the huge development of technology in all areas there has observed a difficulty in following and learning all the changes. Hardware and software is changing and developing every day. This will lead to new young people who have higher efficiency in the modern technology and a greater level of understanding it.

Another reason that makes fotogrammetry an ideal tool for archaeological surveys is the ability of producing fast and accurate detailed archives of photos which we could shoot in each single step of the excavation. It has been proven that the best way to take the photos is from the air. But we want to reduce the cost of taking the appropriate photos, to reduce the altitude from which we take the photos in order to gain higher accuracy. We need also to improve the final plans to be better for the needs of the archaeologists with the maximum information. And finally we want the fastest and low cost way both in the field and in the office. Having the intention to bring all those benefits to the archaeological sites we were lead to the following solution.

According to the above mentioned we seek for the ideal way for the site surveys, and we chose the use of a model remote controlled helicopter which has only one disadvantage and that is the need of an experienced operator. But once you have the person, everything else is in advantage of it. Because with the appropriate adjustments we mount a semi metric calibrated camera Rolleiflex 6006 with motor drive and a 80mm lens. We have the ability to rotate the camera and use it with a remote control. It has been taken care that the gravity centre of the camera will always be on the same vertical axis exactly under and on the axis of the main rotor of the helicopter. Also the tray which holds the camera is suspended on five elastic absorbers in order to eliminate the effect of the vibration of the rotor on the camera system. The helicopter is a Vario Benzin Trainer model with some small changes in its basic configuration such as the longer blades and the more powerful engine we used. Another change was the new landing system, because between the new legs of this system there is the tray that holds the camera. In figure 1 we can see the model helicopter taking photos in the archaeological site of Rentina.

Figure 1. The model helicopter taking photos in Rentina

3. APPLICATION

After the model has been build and tested we surveyed a site in Lefkopetra and another one which was a country house in Asprovalta area. Both sites were found during the construction works of Egnatia which is a main road in North Greece. In the following we have a brief description of the second effort and some thoughts on the cost analysis of this example. In the beginning we put ten targets which have been measured with total station and GPS in order to establish the control point network in the site. After that we flew the helicopter at 30-40m height and we took 24 positive photos at a scale of 1:400 to 1:500. This was needed one foul to the model and we have to land the model once to change the film. The total operation time was 2 hours, including the survey of the control points. The mission was just two persons; one of them was the operator of

the Helicopter and the other the operator of the camera. The one that operates the camera was an experienced surveyor who was leading the operator where to fly the model in order to take the right shots. After 4 weeks another series of photos was taken because we wanted to register the progress of the excavation. From the photos that we took 5 have been used to produce the orthophoto shown in fig. 2. The black crosses in this figure are the crosses from the back of the camera.

Figure 2. Orthophotomosaic produced from the photos

In the office we scanned the photos, we solve the aerotriangulation using the data for the control points, we produce the DTM in order to create the orthophotomap and then we compose the mosaic of the orthophotos (fig. 2). This is an one man work for 10 days after the film developing. The final products are orthophotos at a scale of 1:100 and 1:50. Also a plan was drawn at a scale of 1:50 (fig. 3).

4. CONCLUSION

The choice we made to use the model helicopter as platform to take the photos for surveying archaeological sites has:

- Reduced the time needed for preparing the effort
- Reduced the cost of taking the aerial photos of the site
- Reduced the disturbance of the people working in the site
- Reduced the total work time for making the survey
- Reduced the flight altitude giving grater scales and details
- Reduced the time of process for the final product
- Gave an ideal product with all the information

Apart from the above mentioned the difference between the orthophoto and the drawing can easily be detectable as we observe figures 2 and 3, those plans have exactly the same accuracy while the time and the cost needed to form the drawing is three times the time needed to compose the orthophoto. On the other hand on the drawing we can see only lines which have been interpreted from the operator of the photogrammetric station, sometimes the archaeologist has difficulties in understanding those lines while on the orthophoto anybody can easily recognise details and colours. This gives the opportunity of a better interpretation and at the same time we have available all the geometric information of the drawing.

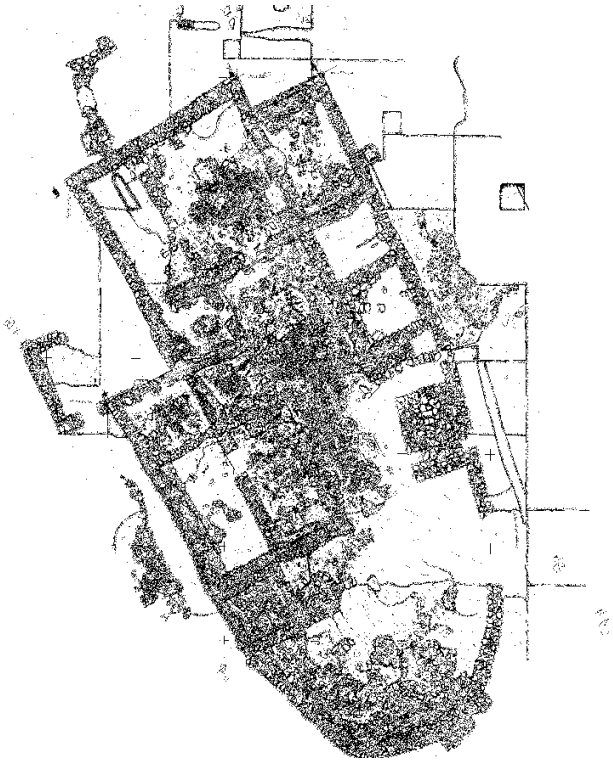

Figure 3. Detailed plan of the excavation

Another application that is in research for the time is the use of infrared films in different daytime and in different types of soil with observations on the ground humidity in order to seek whether is possible to locate underground findings for archaeological purposes. This effort is really in the very beginning for our team and we have no results yet but we believe that there is a lot of consideration in this.

However using the above mentioned techniques for surveying the archaeological sites gives the ability of creating dynamic 3D models using the virtual reality methods. It is very easy using s/w to inspect the site virtually, to walk through, and to view from various points the findings and even more to take measurements on this 3D model. In fig. 4 we can see the site that has been surveyed in a 3D model.

REFERENCES

Georgopoulos A., Nakos B., Mastoris D., Skarlatos D., Three Dimensional Visualisation of the Built Environment Using Digital Orthophotography, *Photogrammetric Record* 15(90):913-921, 1997

Dallas R. W. A., Architectural and Archaeological Photogrammetry, Close Range Photogrammetry and Machine

Vision, Atkinson Whittles Publishing, pp:283-302, Scotland 1996

Gruen A., TOBAGO-a Semi Automated Approach for the Generation of 3-D Building Models, *ISPRS Journal* 53/1998

Ito J., Tokmakidis K., Mamoto E. Visualization of Classical Sites by 3D Computer Graphics, ISPRS Hakodate 1998

Patias, Architectural Photogrammetry Goes to the Digital Darkroom, ISPRS Delphi 1991

Skarlatos D., Orthophotograph Production in Urban Areas, *Photogrammetric Record* 16(94):643-650, 1998

Theodoridou S., Tokmakidis K., Skarlatos D., Use of Radio-Controlled Model Helicopters in archaeology Surveying and in Building Construction Industry, ISPRS Amsterdam 2000

Tokmakidis K., Ito J., Mamoto E., Mori F., Detail Surveys with Close-Range Photogrammetry in Archaeological Sites, ISPRS Hakodate 1998

Tokmakidis K., Ito J., Inada K., Applied Surveys in Archaeological Sites, ISPRS Thessaloniki 1999

Tokmakidis K., Ito J., Inada K., Surveys in Archaeological Sites for 3D Modelling, ISPRS Amsterdam 2000

Figure 4. 3D model of the excavation