EVALUATION OF A THEATRE BY USING LOW-ALTITUDE AERIAL AND TERRESTRIAL PHOTOGRAMMETRY

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ABSTRACT:

This study describes a special application of aerial photogrammetry. A digital camera, mounted under a balloon has been used for taking aerial photos. The plan of the antique theatre in Patara had to be mapped out of photogrammetric stereo-models, which have been generated from the photos. Taken from the Helium-balloon, the photos view the area from an altitude of 30 to 40 meters. This altitude is fine for a suitable ground resolution of 5 cm. Another parameter for the flight altitude was the lift force of the balloon, which has a limit to approx. 50 m for this application. Computer CDs have been used as ground control points, which were painted with blue colour, so that they wouldn't reflect for being clearly visible. The entire area was marked by approximately 80 of such ground control points. They have been measured by classical terrestrial methods with a Pentax ATS 102 total station. For the facades of the theatre, classical terrestrial photogrammetric methods have been used. Some stone corners have been taken as additional control points. Their positions have been mapped onto a sketch.

The evaluation process has been done using Pictran and AutoCAD software. At the end of the study, a detailed layout plan, some profiles and plans of all facades has been evaluated.

In an ongoing study, photogrammetric tests with PhoTopoL-Atlas Software are running with the goal to create an accurate 3d model with animations of the theatre. Further on, the data should be stored in GIS application as well to be part of web-based GIS-application for tourist affairs and as well as for archaeological reconstruction aims.

1. INTRODUCTION

Photogrammetry is a very suitable evaluation technique for many complex objects. It is widely used for documentation of archaeological heritage. For this purpose, terrestrial images are used for a long time, both, for facades and ground plans. Digital photogrammetric techniques allow evaluating oblique photographs but in most cases this kind of photos make the exterior orientation difficult and the evaluation progress much longer. This disadvantage appears especially by drawing maps of the study areas.

As well known, aerial images are most suitable database for evaluating and mapping objects. But the high-cost of aircraft campaigns force the scientists and photogrametrists to think about cheaper solutions especially for smaller areas. These solutions are: (Leloglu et all.)

- Kite
- Balloon
- Remote controlled model helicopter
- Remote controlled model aircraft

Some of these solutions have already tested for remote sensing, archaeological documentation, change detection etc. A 28 mm camera hanged up to the balloon has been used for change detection purposes from 100-200 m in height (Miyamoto et al.) Another low-altitude aerial photogrammetric application was done about archaeological documentation with a 35mm camera mounted under a balloon from 31m height (Karras et al.).

2. IMAGE ACQUISITON AND PLATFORM

2.1 Study Area

Patara is an ancient city placed in the southern part of Turkey, situated at the Mediterranean coast near Kalkan, between Fethiye and Antalya. Patara, founded about 500 BC, was the major port of the Lycian empire, located at the mouth of the Xanthos River. Patara was enlarged under Alexander the great in the year 333 BC. Around the year 300, St. Nicholas was born in Patara and was active in this region.

The city was later running out of interest and destroyed by the sand-accumulation of the Xanthos-river at the seaside, where wind filled the harbor and big parts of the city with dunes. In the last few years, big activities have been undertaken with excavation of the buildings, especially of the theatre. The theatre was exempted from several hundreds of lorries of sand. Since several years, groups of Turkey archaeological scientists aim to open the history of Patara. To get a detailed geodetic map of it, there came the request to the ITU. For this job, the balloon system seemed to be a worth full technology to map it. The first objective of the study was the theatre in this archaeological site. The theatre is about 80x100 m big.

2.2 Control Points

As control points for aerial photogrammetry, compact disks have been used. In order to reduce the reflectance, all of them were painted blue and red/white stickers have been plastered onto them as a measure marks. 80 ground control points were used for all the theater. (Figure 1)

Another type of control points was defined for the terrestrial photogrammetry for facades. Corners of stone blocks have been chosen for this purpose.

All of them have been measured by terrestrial methods with a total station Pentax ATS 102.

Figure 1. Layout view and control points

2.3 Image Acquisition

Aerial images have been acquired from a helium balloon with an Olympus C-4040. Balloon was 2.5 m in diameter and has a volume of approx.8 m^3. It can lift up to 8 kg, so the optimisation of platform and the camera on the balloon has a big importance about the weight of them. The camera and platform have been selected and built so that their weight will be minimum. Even the ropes have been selected so that they would be strong enough for this balloon and minimum in weight.

The balloon carries an aluminium frame as a camera platform and this platform is hanged downside of the balloon using 6 ropes. The camera platform was built in the workshop of GGS in Speyer. The digital camera was fixed at a axe, which itself was connected to the triangle frame, turn able around 2 axes so that the weight of the camera forced the platform, to support always a nadir view of the camera (Figure 2). To reduce the swinging of the platform, a smooth-compensator was built in. Phi and Omega values should be small with this construction, Kappa had to be influenced by the rotation of the balloon.

Figure 2. The camera and its special-designed platform

To the ground the balloon was fixed with 3 ropes, each with 50m length. One rope was used as carrier for a video and a remote-control wire.

The video-out port of the camera was used to transmit the cameras view to the ground. The normal PAL-signal was send through a coaxial wire. A small portable TV with a video-in plug and battery power was used as a cheap monitor solution. A frame protected the screen against direct sunlight and the control worked fine (Figure 3).

Figure 3. Ground control unit with monitor and remote control

The wireless infrared control of the camera was rebuilt and the IR LED was connected to a thin wire and fixed before the Sensor at the Camera. IR signal only bridge short distance (max 10 m) and have problems in hot air conditions. Both worked fine even with 50 m wired connection, video control and the remote control of the camera. Also the sharpness of an image has been visible when the image was frozen for a few seconds when the camera had shot the photo.

Figure 4. Balloon during flight campaign

For all the theater, 214 aerial and 275 terrestrial photos are taken. Aerial photos have been used for mapping the plan where terrestrial photos for evaluation of facades.

On the aerial photos, ground control points are clearly visible. This was the result of painting them blue, so that the effect of reflectance had been minimized (Figure 5). On terrestrial photos, there wasn't a reflectance of control points, because some details on the photos such as stone corners etc. have been used as control points (Figure 6)

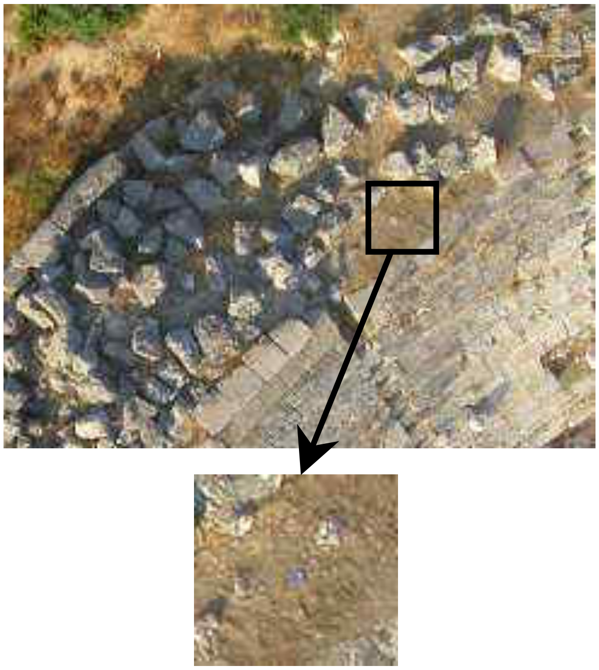

Figure 5. Aerial photo taken from the balloon and a control point zoomed in.

Figure 6. Terrestrial photo

3. PHOTOGRAMMETRIC EVALUATION

For photogrammetric evaluation, Pictran software has been used. Exterior orientation of the aerial imagery was unproblematic due to the position of the camera (almost vertical) and the coordinate accuracy of control point. The control points have been measured with 2-3 mm accuracy in X, Y and ~4 mm. in Z direction. The geometric accuracy of evaluation results for aerial images was about 4 cm.

Exterior orientation was fine also because of the geometric accuracy of control points and their distribution over the images. Using only the ground control points, exterior orientation was already fine but some tie points have been measured for getting better stabilization in the aero-triangulation.

Difficulty of this study was the exterior orientation of terrestrial images. In some parts of the study area, the images had to be taken very closed to the object of interest. That caused, that the single image covers a small area. Therefore many control points on the facades had to be measured. Nearby, the obliquity of the photos forced some additional problems. In that case, the exterior orientation of some facades have been a big work and needed long.

By photogrammetric evaluation, over 100.000 points have been measured three dimensionally. This step was the biggest work of the whole study. The measured 3-D coordinates of the stones and their contours have been transferred in CAD-Software. Editing and some additional cartographic works have been done using AutoCAD.

At the end of the study, following maps with different scale mentioned below have been created.

- Layout plan (1:250)
- Detailed plan (1:100) (Figure 8)
- Drawing of 12 facades (1:50) (Figure 9)
- 5 Profiles (1:50)

4. FURTHER ACTIVITIES

The processing of the data is at least a big work, especially if we use point-based systems. The possibilities of PhoTopoL Software are, to be able to digitise directly lines in 3D and to control them in stereo. This is possible for aerial images as well as for terrestrial photographs. With some limits to resolution and accuracy, also oblique photos can be processed. Further on, the orthophoto production in such a system is possible, which reduces the need to map all lines and increases the information on the map dramatically. An example is given below. Such tools are the key for complex 3D modelling up to the creation of visualisations and animations. This will be tested.
In this frame, the data can be stored in GIS application as well to be part of web-based GIS-application for tourist affairs and as well as for archaeological reconstruction aims.

Figure 7. First results of edge mapping in PhoTopoL with computed orthophoto

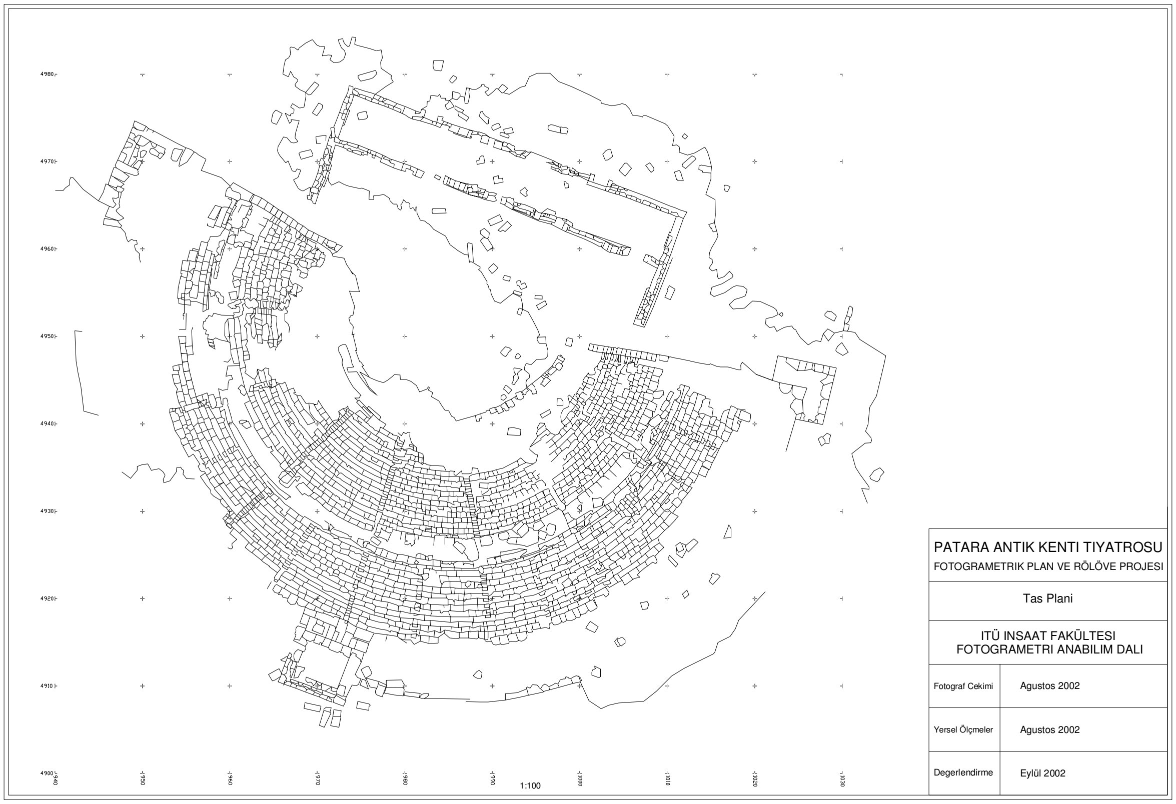

Figure 8. Detailed plan (original 1:100)

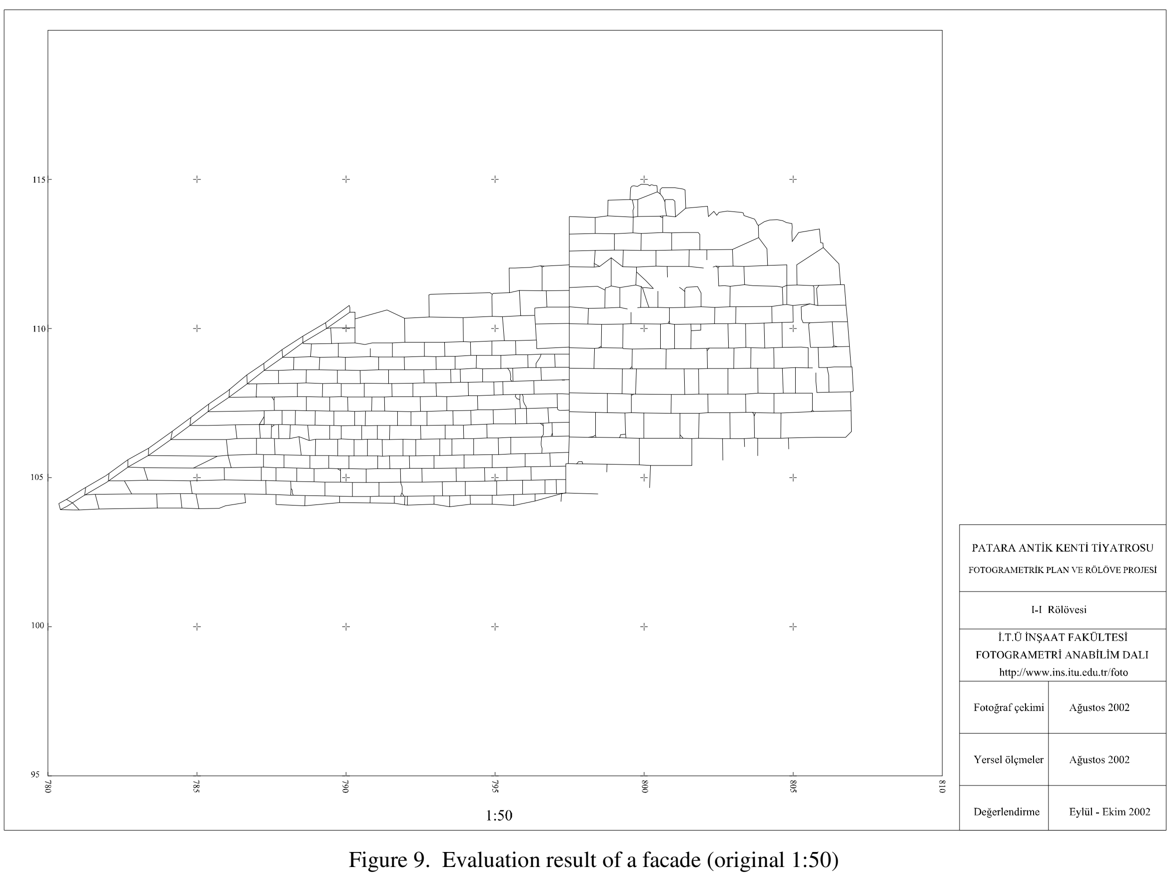

Figure 9. Evaluation result of a facade (original 1:50)

5. CONCLUSIONS

Evaluation of ancient settlements and cultural heritage has always been one of the most interesting topics in photogrammetry. One of the difficulties by archaeological photogrammetry is the position of the camera. Suitable camera position cannot be arranged in any cases. In this study, a different platform has been used for image acquisition. The interesting point of the image acquisition system is the availability of the covering area in the monitor by the ground operator. This causes more effective work on the field. Another interesting point is the structure of the camera holder, so that it acts likely as a compensator. This causes to take more suitable photos for photogrammetric applications.

In archaeological sites, excavations take place mostly in summer. This causes – especially in Mediterranean part of Turkey- to work in hot weather. Thinking about the contrast on the images, this was a disadvantage. Because of that, image acquisition has been done very early in the morning. Nearby, in those hours, it is very silent and not windy. This is an advantage for using the helium-balloon too.

It is well known that oblique photos have some problem during exterior orientation. But in some cases like facade evaluation etc. this is a must, if any of the additional equipment has been used. Ongoing study is to use the balloon and the camera for façade imaging especially for tall or non-reachable building.

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