

PHOTOGRAMMETRIC DOCUMENTATION AND VISUALIZATION OF CHOLI MINARET AND GREAT CITADEL IN ERBIL/IRAQ

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ABSTRACT:

In 2006, two Czech expeditions were dispatched to Erbil with the aim of basic monument documentation, archaeological investigation and finding appropriate technology for the restoration of these structures. The first step was the photogrammetric and geodetic measurement of the Great Citadel and the Choli minaret in Erbil. The Citadel spreads out over more than ten hectares of land (300m-350m in diameter). The Choli minaret was documented by terrestrial digital photogrammetry by using a calibrated digital camera Canon 20d and RolleiMetric system. Photomodeler and AutoCAD software were used along with classical geodetic measurement to create a 3D model and texture it with the images. In case of the Citadel, a set of terrestrial digital images were taken (over 250 of the outer side of the Citadel and 200 of the inside); next approximately 70 images were taken from a US Army helicopter flying at the approximate height of 50-150 meters. In Iraq there are currently no photogrammetric aerial images available; in this case a satellite image from the QuickBird satellite, with a resolution of 65cm, was used for the ground plan of the Citadel. A provisory geodetic network in the Citadel area was built and over 600 object points were geodetically measured. Next, 16 control points for aerial imaging were signalled and measured, mainly on the roofs. Nowadays, we are working on creating a vector plan of the Citadel. We are also working on processing photogrammetrical images onto virtual 3D models of the Citadel fortification and of the valuable objects inside. The last part of this project consists of creating an information system for the Citadel, which will be used for the storage of all of his information.

1. MONUMENTS IN IRAQ/ERBIL

1.1 Documentation of historical monuments

In Iraq, there are a lot of very valuable historical monuments. A great deal of monuments is in a very poor condition. An urgent need for preservation of the most important architectural monuments arose in conjunction with the post-war reconstruction of Iraqi culture. Architectural monuments were often damaged by the war and today even simple preservation is nearly impossible.

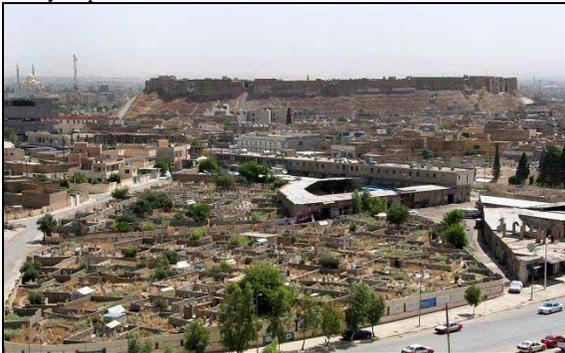


Figure 1. Great Citadela in Erbil

Most of the architectural monuments suffered from lack of interest of state authorities under Saddam Hussein's Republic and their condition, even before latest conflict ended in most cases, could be described no less than critical. Erbil is an

ancient city, originally Sumerian and Assyrian, located in the foothills of the eastern Iraqi mountains. It is a commercial, cultural, agricultural and administrative centre of the Kurdish region. In the historic centre of Erbil, there are two historical monuments known worldwide: The minaret at Choli and the Great Citadel.

The Citadel in Erbil is on UNESCO's list of the world's most endangered historic sites. It forms a vast complex of buildings and narrow streets enclosed by town walls. The Citadel in Erbil is one of the oldest continuously inhabited urban settlements in the world. According to ICOMOS data, eight thousand years of inhabitation are proved in this unique urban concentration, making it the longest inhabited place on the Earth. This has been made possible by rich water sources, still available today, which have never dried out in recorded history. The fortified Citadel itself is situated on an artificial elevation of 28 to 32 meters above the surrounding countryside, which is now the city of Erbil. Well-known records and archaeological finds proved layers of Assyrian, Akkadian, Babylonian, Persian and Greek Pre-Arabic settlements. Fortifications were primarily built in the 12th century. At the moment the number of inhabitants of the historic city centre (5,000-5,500) is rapidly declining. The regional government of Kurdistan is looking for opportunities to revitalize and preserve this unique complex for the significant rise in tourism that is expected in the future. Water for households is pumped into steel tanks on the roofs and water is distributed by gravity. Electrical wiring is situated on the posts and the house elevations. There is no sanitation in the Citadel and the remaining inhabitants use dry toilets, which result in all the expected health and hygiene hazards.

The Choli minaret is from the 14th century and it is the last part of the oldest Kurdish mosque. It is ranked among most significant Kurdish monuments and its condition is alarming owing to the tilting of the upper part of the minaret. The lower seven-angle part of the minaret is 12 m high. The circular part of the minaret is about 24 m high and shelters a double spiral staircase. As stated by the owner, the thickness of the wall is around 36 cm. The minaret lost its upper part in the distant past. Since then it has been open to weathering and to rainwater leakage in particular. Precious historic fragments of renderings and embossments have been identified on the lower part of the structure; particularly large-scale findings of stucco decoration were found in niches of the tower. All fragments of stucco decorations are seriously affected by weathering and mechanical damage.



Figure 2. Great Citadela in Erbil (QuickBird, 2005)

1.2 Choli minaret

The upper part of the minaret diverts from the vertical axis to 65cm and there is a substantial threat of it collapsing.



Figure 3. Choli minaret; original photo and animation (rendered 3D model)

Calibrated digital cameras, réseau photogrammetric camera RolleiMetric 6006 and total station were used for the basic

documentation of the Choli minaret. Conducting the necessary geodetic measurement at a temperature of around 45°C proved to be very difficult. The total station experienced some problems with the LCD display; the measurement on the upper part of the Choli minaret was very problematic without a special zenith extension. A small provisional geodetic network consisting of 4 points was stabilised by the usage of nails and plastic marks. First of all, network point adjustments have been made on site (all calculations have been carried out in Erbil for the controls). The results were satisfactory for this purpose: about 7mm in position.

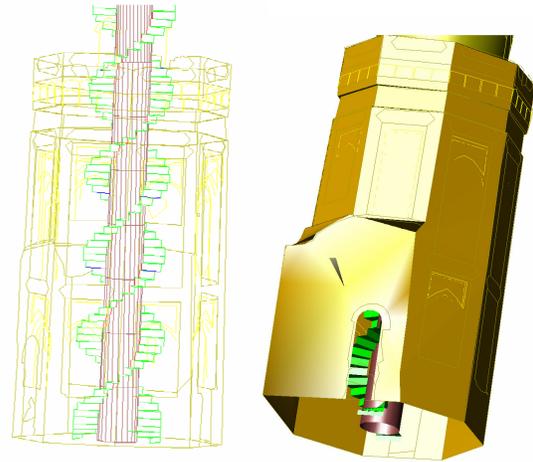


Figure 4. Vector 3D model of the Choli

After all the necessary control points and object points were measured with accuracy of about 1-2cm in position (all common and well visible points were measured, no special target has been utilized - hand-drawn marks on the lower part of the minaret). Altogether approximately 250 points were measured. A set of 25 digital photogrammetric images have been taken using the Canon 20D digital camera with a resolution of 8 MegaPixels.

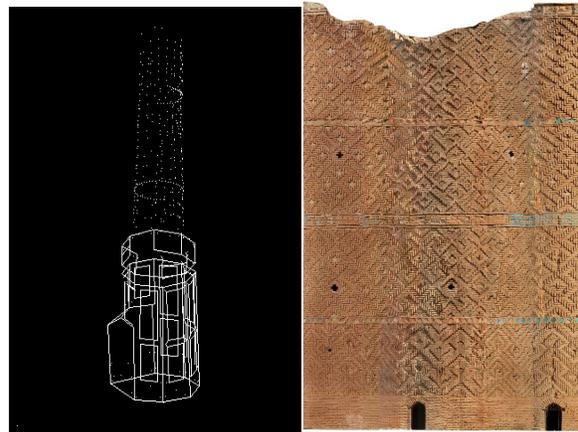


Figure 5. Vector 3D model of the Choli minaret (Photomodeler); unwrapped upper part of minaret

This particular camera was calibrated by using Photomodeler software in the Laboratory of Photogrammetry at the CTU in Prague. The zoom equipped lenses were calibrated on focal lengths 10, 22 and 17, 85mm. The Rollei réseau camera takes

12 images on classical non-perforated colour film in the 6x6cm format. Both 40mm and 80mm lenses were used, 3 rolls of film were taken (36 images). Upon completion of the expedition all the images taken were scanned using a professional film scanner (Nikon CoolScan 8000) at true 2500DPI.

The outdoor parts of the Choli minaret were measured and processed by using intersection terrestrial photogrammetry in the Photomodeler software (residuals on control points were about 2cm, indoor parts were measured with tape for construction in AutoCAD only. From these measurements the following outputs were created: a real 3D model for static modelling and calculations, true-photo rendered 3D model with animation, classical photo plans of lower part and unwrapping of upper minaret's tube. All construction, animation and editing of photogrammetrical measured items were processed in AutoCAD.

1.3 Great Citadel

The Citadel is spread out over more than ten hectares of land (300-350m in diameter). It is a classical example of an adapted hillock - "tell". The height of the hillock averages around 30m above the flat surroundings. No maps or plans were available to us of the Citadel— only a copy of a cadastral plan from the 1920's... During the 20th century, the great Citadel was heavily damaged by the Saddam Hussein regime since it was a symbol of importance for Kurdish people. Major parts of houses and palaces inside the Citadel were destroyed; the original major portal was completely demolished. In the 1980's a new, modern, main portal was built in a retro style. The last repairs on the Citadel were conducted in the year 1982. During this year seven houses were conserved. Today the Citadel urgently requires conservation. This is a lengthy and expensive activity; and in order to begin the restoration documentation of the actual state of affairs is necessary.

During the short time of the expedition it was not possible to collect a detailed documentation of this structure. Instead, terrestrial and aerial photogrammetry was utilized. In Citadel's case, a set of terrestrial digital images were taken (more than 250 outside the Citadel and 200 inside); the next 70 images were taken from a US Army helicopter at the height of approximately 100m. In Iraq, there are no available photogrammetric aerial images; instead, a satellite image from the QuickBird satellite with a resolution of 65cm was used for the ground plan of the Citadel (date of image acquisition: 2005, 23.8.). The satellite image was processed by using Geomatica 10.0 (pan-sharpening) and Adobe Photoshop 7.0 (the image sharpening, filtration and new sampling to 25cm pixel were used for image quality improvements). The outputs of this procedure are encouraging and enable the next step to process with better quality.

A provisory geodetic network in the Citadel area was built and over 600 object points were geodetically measured. Next, 16 control points were signalled and measured for aerial imaging, mainly on the roofs. The Photomodeler software was used for all photogrammetric image processing. The 33 aerial images and 19 terrestrial images were adjusted to the base model. The mathematical least square adjustment and absolute transformation utilizing the control points was sufficiently accurate: the mean coordinate's error of control points was approximately 15cm (mean position error 20cm). In the 3D model about 1000 object points were measured and calculated.

A comparison of geodetically measured and Photomodeler calculated object points was made; a small systematic and scale error has been found (the model from

Photomodeler was a little bit bigger and moved to south; the typical differences were approximately 15-30cm in comparison to geodetic measurement by total station). These displacements were solved by affine transformation into the geodetical measurements.

Finally, we had geodetically measured object points, points from Photomodeler processing, measured control points and a transformed satellite photo plan (as an under layer photo plan). These data were then used for processing to the base vector plan.

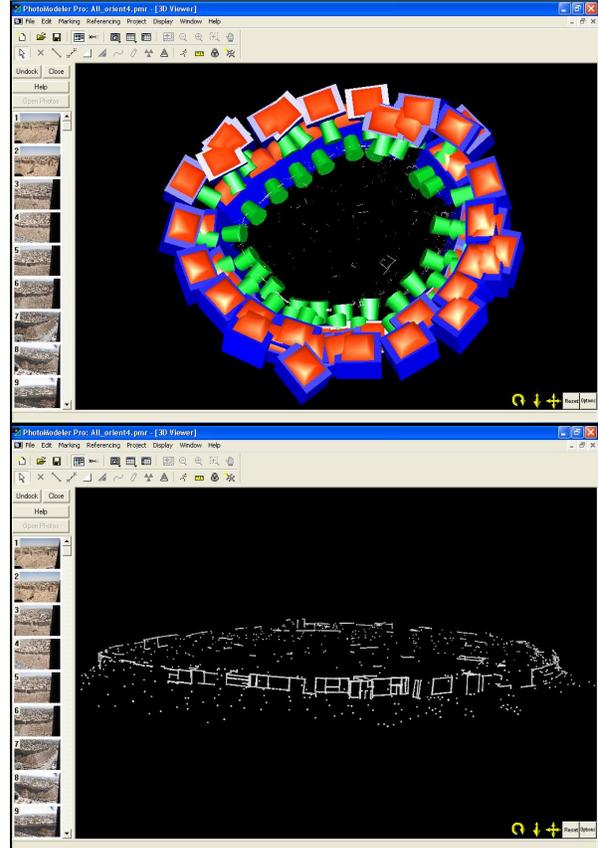


Figure 6. The Great Citadel: image data processing in Photomodeler



Figure 7. Vectorisation of satellite image

2. FUTURE WORKS

Nowadays, we work on the creation of a final base vector plan of the Citadel (no utilizable vector or photo plan was found - only above mentioned copy of old Arabic cadastral schema from the year 1920). We also computerize photogrammetrical images to virtual 3D models of the Citadel fortification and the valuable objects inside (a big inside part was goal-directed damaged and the today's inhabitancies are provisory – as a slum). The last part of this project is the creation of an information system for the Citadel, which will be used for the storage of all valuable information.

2.1 Acknowledgements

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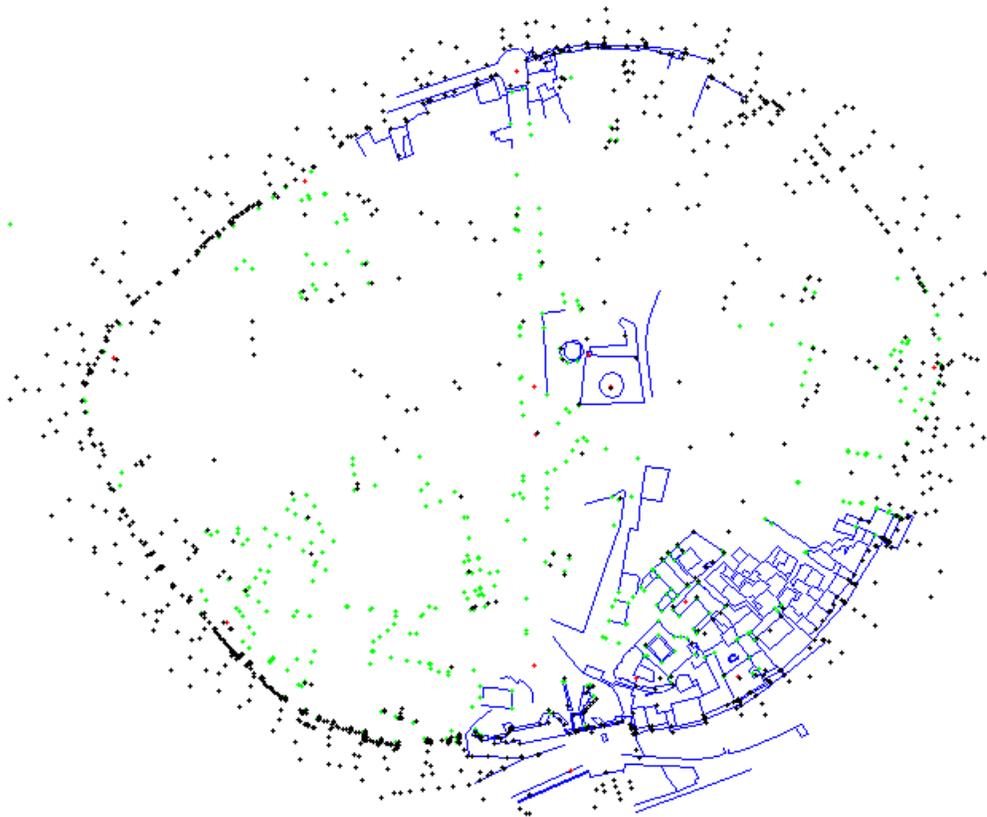


Figure 7. Measured data: black (Photomodeler), green (total station), red (control and geodetic points), blue (vectorisation of satellite image, 5/2007)



Figure 7. Pan-sharpened satellite data: comparison of Quick Bird (left) and Ikonos (right)



Figure 8. Original aerial image from US helicopter



Figure 9. Image enhancement (left: original satellite image, right: filtered image)



Figure10. Vectorisation of satellite image