



PHOTOGRAMMETRIC SURVEY AND 3D MODELING OF IVRIZ ROCK RELIEF IN LATE HITTITE ERA

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ABSTRACT

In this study, the photogrammetric measurement technique was used to document the Ivriz relief, which is located under the Kocaburun Rock on Mount Aydos in the village of Ivriz (Aydıncıkent), Konya-Eregli. This relief has been standing since B.C. 720 but suffers from man and environmental agents. It has been standing high from ground on rock façade. Therefore a 3D (three-dimensional) model of the monument was obtained as a result of the work conducted for protection. Conservation has been done by close-range photogrammetry technique. Using close-range photogrammetry, in which only some brief field work was done with a majority of the other work being conducted in an office, documentation can be efficiently performed using free equipment and software as well as scaled archives to produce three-dimensional models of historical and cultural heritages in a digital environment.

KEYWORDS: Ivriz, Close-range Photogrammetry, Cultural Heritage

1. INTRODUCTION

Many of our historical and cultural heritages suffer serious damage caused by a lack of care or natural disasters, and consequently, they disappear. Digital close-range photogrammetry is one of the leading methods for documenting cultural and historical heritages. According to the records of the Ministry of Culture and Tourism from 2010, there are a total of 94388 registered cultural and historical assets in Anatolia and 1394 in Konya (URL.1, 2010).

The geometrical documentation of archaeological monuments can be defined as the measurement, evaluation, registration and presentation is required to determine the present state, i.e., the dimension, shape and position, of a historical or a cultural structure in a three-dimensional space (Georgopoulos and Ioannidis, 2004).

Various methods are currently used to document historical and cultural heritages. Three-dimensional modelling and imaging of historical and cultural heritages is a complex and multi-faceted part of this documentation (Kulur and Yilmazturk, 2005). Digital close-

range photogrammetry is a very effective and useful method for documenting these heritages.

This paper is an application of digital close-range photogrammetry to Ivriz relief for the precise 3D digitization and visualization. It includes knowledge about the relief and the fundamental steps of the 3D relief modeling with photogrammetric techniques.

The measurements of 3D modeling and documentation have been presented for a relief near Ivriz, which was a very important place from a religious heritage perspective that showed a continuation of the cult tradition during the Hittite Empire Era. The Ivriz rock relief was first time mentioned in Cihannuma (Çelebi, 1732), a famous book by an Ottoman traveller named Katip Çelebi. It has been familiar to the scientific world since the 18th century, and substantial many articles have been written about it (Çelebi, 1732; Messerschmidt, 1906).

2. THE HITTITES AND THE IVRIZ ROCK RELIEF

Rock relief is in situ on cliff near abundant spring at Ivriz in the north foothills of Taurus range, near modern Ereğli (Fig. 1).



Figure 1: Location of Ivriz Relief

Later eighth century B.C. Excavated sites of the Neo-Hittite period on the Anatolian plateau are rare and surviving monuments scarce except for a group dating from the second half of the eighth century B.C. Among these the sculptures associated with Warpalawas of Tuwana (=classical Tyana, the modern province of

Niğde) are outstanding. The rock relief, deservedly one of the best known monuments of its age, shows on the right the small figure of the king Warpalawas in attitude of adoration; and on left the massive figure of the god, 'Tarkhunzas of the Vineyard' as he is named on another Warpalawas inscription, from whose feet grain

and vines spring up. The god is shown in traditional gear rendered in modernized style, his axe and thunderbolt replaced by symbols of generous fertility. The king is richly dressed and the carefully rendered details of his fibula and the embroidery of his clothing are striking. Warpalawas is attested as tributary to Tiglath-pileser III in 738 and 732 B.C., and was still on throne in about 710 B.C., doubtless one of the most prominent of the surviving Neo-Hittite kings of the Anatolian plateau, caught between the pressures of Phrygia (B.C. 700) and Assria (B.C. 605). Briefly, the Ivriz relief is really important relief for reflecting the features of the Late Hittite Period (Boardman, 1984).

A relief depicting god (Tarkhunzas) on a 4.30x3.40 m panel, with a base length of 0.90 m, skirt width of 1.95 m, and shoulder width of 1.90 m. The image most likely has an earring in the ear and is wearing a waistcloth with a fishbone pattern, has a hilt shaped like a small-eyed, large-beaked eagle (Barnett, 1983), and a large V-shaped, voluted skirt. The figure's braceleted right hand holds a bunch of grapes, whereas its braceleted, folded and raised left hand holds wheat ears that reach down to the figure's shoes. Unlike the richly ornamented relief of a king that is opposite the god, the god's relief is quite plain and has muscular, bare legs and large knee caps.

Opposite the god's relief is King Warpalawas's relief, which is 2.95 m in length and in a worshipful position. In line with the king's relief and the god's relief is a three-line hieroglyph:

"This is Warpalawas's Great Storm God (Tarkhunzas)." (Hawkins, 2000)

This relief with the god and king was made by the Aramaic king Warpalawas for the Hittite and Luwi peoples in 720 B.C. (Akurgal, 1987).

Directly behind the highly ornamented skirt of the king's relief reads a three-lined hieroglyphic inscription that is spaced at 0.36, 0.32, and 0.27 m:

"This is a depiction of Brave Warpalawas."

In addition to representing an important religious centre that reflects the Hittite Imperial Period cult tradition of the Middle Iron Age, Ivriz is situated at a crossroads and may have served as another political centre for Warpalawas (Karauğuz, 2006).

3. DOCUMENTATION METHODS

The selection of the appropriate scope, level, and methods of recording require that the methods of recording and type of produced documentation should be appropriate to the nature and importance of the heritage place, the project needs, the purpose of the record, the cultural context, and there sources available. Preference should be given to nonintrusive techniques. The rationale for the intended scope and for the selection of the recording method must be clearly stated, and the tools and materials used for compiling final records must be stable. The recommended framework for development and use of recording tools and technologies can be choosing for expected accuracy (Letellier et al, 2007).

Various methods can be used to evaluate and document cultural assets (Böhler and Heinz, 1999; Arias et al., 2005; Scherer, 2002, Chueca et al., 1996). These methods can separate in two groups, first one is traditional methods and the other is technological methods. Traditional survey techniques and topographic methods are useless for documentation at present. Because of the improvement of technology, many remote and active sensors have been using to document of objects and in archaeological sites for the last decade (Akca, 2012). Laser scanning technique and close-range photogrammetry techniques are the newest methods. These techniques do not need to physical contact to object. However, laser scanning technique is very expensive and data processing steps are too complex for assessment of point clouds (Bornaz and Rinaudo, 2004; Nuttens et al., 2010). In this paper low-cost photogrammetric technique has used for conservation of relief. It has chosen cause of the technique is inexpensive and easier to create and acquire information about the objects with conventional cameras. Our cultural heritage must be preserved so that the assets are not destroyed, converted or subjected to any type of intervention.

3.1 Close-range Photogrammetry Technique

Close-range photogrammetry is a method that allows the construction of close- and far-range two-dimensional drawings, and after necessary orientation using special assessment

software, three-dimensional models can be raised from the surface of the photographs with the help of single and dual cameras. This method is used to obtain 3D positioning information about an object (Toz and Duran, 2004). Photogrammetry has been used in the past many decades as a tool that provides assistance in recording cultural heritage and is useful for modelling and for taking 3D measurements (Arias *et al.*, 2007).

The fact that the measurement time is very short is the most important feature of photogrammetry. This method is one of the most precise, reliable, economic and rapid methods that is currently available. In photogrammetric archiving, it is possible to take measurements after a certain time or when a new measurement is needed by consulting the archives without having to go to the field. Therefore photogrammetry is often the preferred measurement technique (Arias *et al.*, 2005).

A photogrammetric study can be conducted using cost-effective commercial cameras, and the technique can be used in architecture, archaeology, forensic studies and many engineering applications (Karauguz *et al.*, 2009).

4. PHOTOGRAMMETRIC APPLICATION

This study focused on acquiring data about a sculptural cultural heritage using image-based scanning photogrammetry techniques. In the field study 11 photographs have been captured with fixed focus camera but seven photographs have been used for process. Camera stations can be seen in Fig. 2.

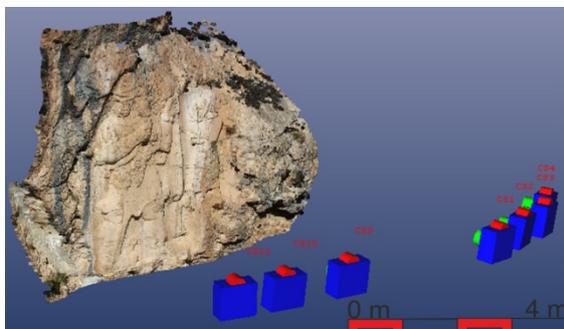


Figure 2: Camera Stations

Focal length is 18.2116 mm. Average distance between images and relief was 6 m. The control point coordinates (x, y, z), which allow orientation, levelling and scaling, were determined in

local coordinate system with a reflectorless Topcon, Japan GPT 3007 series total station. In field study, a local coordinated (x, y, z) measurement of these monuments was taken using methods described by Sienz *et al.* (2000). The distribution of the targets was homogeneous following a model as the principal point distribution in photogrammetry. The ground control points on the relief have been chosen as natural points and sharpness (or the “white-black” corner) and contrast color points.

Control points that were used to determine the reference frame were measured with a non-prism total station with a $\pm 7''$ angular accuracy and in distance measurement accuracy ± 5 mm in non-prism mode. Positional accuracy of the GCP's (Ground Control Points) measured by total station is ± 5 mm. Height accuracy of the GCP's have been changing between $\pm 1-3$ mm. These results are good enough for detailed recording. This recording consists of accurate graphic records for detailed studies and design requirements. This is needed to make easier to understand studies in accordance to the recommendations of the conservation of heritage places (Letellier, 2007).

4.1 Photogrammetric Evaluations

The calibration parameters of the non-metric camera (a Canon EOS 550D digital camera) were obtained under laboratory conditions. The calibration process was completed using the automatic calibration module of the Photomodeler Scanner v.12 photogrammetric software and its grid printout. Twelve photographs were taken for the calibration stage and then imported into the software. Root mean squares (RMS) of the residual were 0.2228 pixels for the camera calibration. The calculated camera parameters of the digital camera are presented in Table 1.

Table 1. Calibration Parameters

Focal Length	18.2116	
Format Size	W:22.6588	H:15.1130
Principal Point	X:11.3591	Y:7.5549
Lens Distortion		
K1: 5.997e-004	P1: 4.491e-005	
K2: -1.210e-006	P2: -1.068e-005	
Overall residual RMS: 0.2228	Maximum Residual: 0.8735	

where K1 and K2 are the first and second order, respectively, of the radial distortion coefficients. The tangential distortion coefficients are P1 and P2. All of the measured coordinate values for the photographs and the camera calibration parameters were imported to the software, which then performed the photogrammetric evaluations. Photogrammetric evaluation steps are shown in Fig. 3.

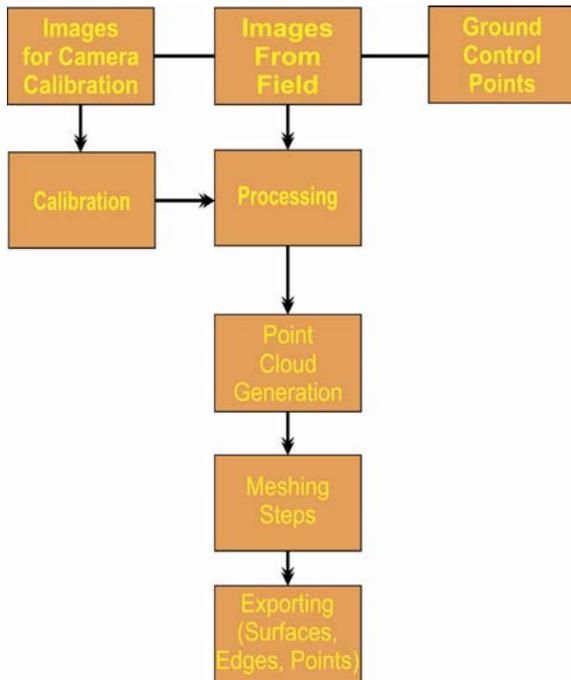


Figure 3: Workflow for Photogrammetric Process

Camera calibration is required to find the true camera parameters at the instant when a photograph is taken. Some of these parameters include focal distance, picture size, photograph centre and lens distortion.

Knowing the interior orientation of the camera is a prerequisite for creating a sensitive photogrammetric object. Currently, photogrammetric camera calibration is performed by calculating the object coordinates together in balancing light beams. There are many commercial software packages that allow for photogrammetrically formed calibration files (Peipe and Tecklenburg, 2006). Once the interior (calibration) parameters are known, 6 exterior orientation parameters remain to be determined, all addressing the 3D translation and rotation. This evaluation is called resection. At least three non-collinear targets, called control points, are

needed for this process. Point A, below, is one example (Fig. 4). When more than 3 control points are available, a more rigorous statistical approach can be used. More information can be obtained from Atkinson (1996).

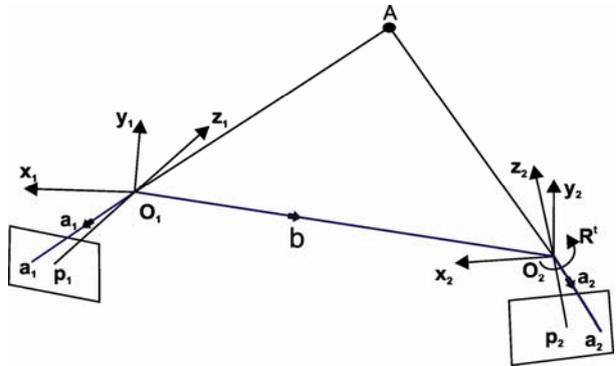


Figure 4: Coplanarity Form

Evaluating the exterior orientation of one camera relative to the photo co-ordinate system of another is known as relative orientation. In Fig. 4, suppose that the photo-coordinate axes (x1, y1, z1) of the image with its perspective centre at O1 are the primary co-ordinates, and that the exterior orientation elements of a second camera with its perspective centre at O2 must be evaluated. Target A is imaged at a1 and at a2. Vectors a1, a2 and b are coplanar and lie in the epipolar plane of target A and the two perspective centres (Atkinson, 1996).

$$a_1 = -\lambda[x'_1 \ y'_1 \ -c]^T$$

$$a_2 = -\mu[x'_2 \ y'_2 \ -c]^T$$

$$b = (b_x \ b_y \ b_z)^T$$

where b is the camera base, R is the rotation matrix. λ and μ are scalars greater than zero whose values influence the parallax vector (p).

The volume of the parallelepiped formed by these three vectors must be equal to zero:

$$b * (a_1 \times a_2) = 0$$

These equations contain 12 unknowns: three coordinates and three orientation angles for each photograph. The coplanarity equation is useful to determine the exterior orientation elements of a camera relative to the photo coordinate system of another one (Atkinson, 1996).

4.2 Photogrammetric Data Processing

The photogrammetric bundle adjustment and processing evaluations were completed with photogrammetric software in office. The orientation of each photo was determined by multi-image triangulation. To connect all of the photos in an overall triangulation photo block, the control points and selected natural tie points were measured by hand for each image. The collinearity condition expresses the basic relationship in which an object point and its image lies on a straight line passing through the perspective centre:

$$\begin{pmatrix} x' - x'_0 \\ y' - y'_0 \\ -c \end{pmatrix} = kR \begin{pmatrix} X - X_C \\ Y - Y_C \\ Z - Z_C \end{pmatrix} \text{ or } a' = kRa$$

- a is the vector from the perspective centre to the point expressed in the object space coordinate system,

- X, Y, Z are the coordinates of the object-point and X_C, Y_C, Z_C are the coordinates of the perspective centre,

- a' is the corresponding vector expressed in the camera space coordinate system (c is the principal distance of the camera, x'_0 and y'_0 are the coordinates of the principal point),

- R is the rotation matrix and k is the scale factor.

The geometric positions of the control points must form volume, i.e., they cannot lie on the same plane. If they do, the collinearity equations will not obtain a reasonable solution for unknown points (Kraus, 2000; Grussenmeyer and Khalil, 2002). In Fig.5, the image point measurements for tie and control points are displayed as an example using the software Photomodeler Scanner from EOS systems, Canada.

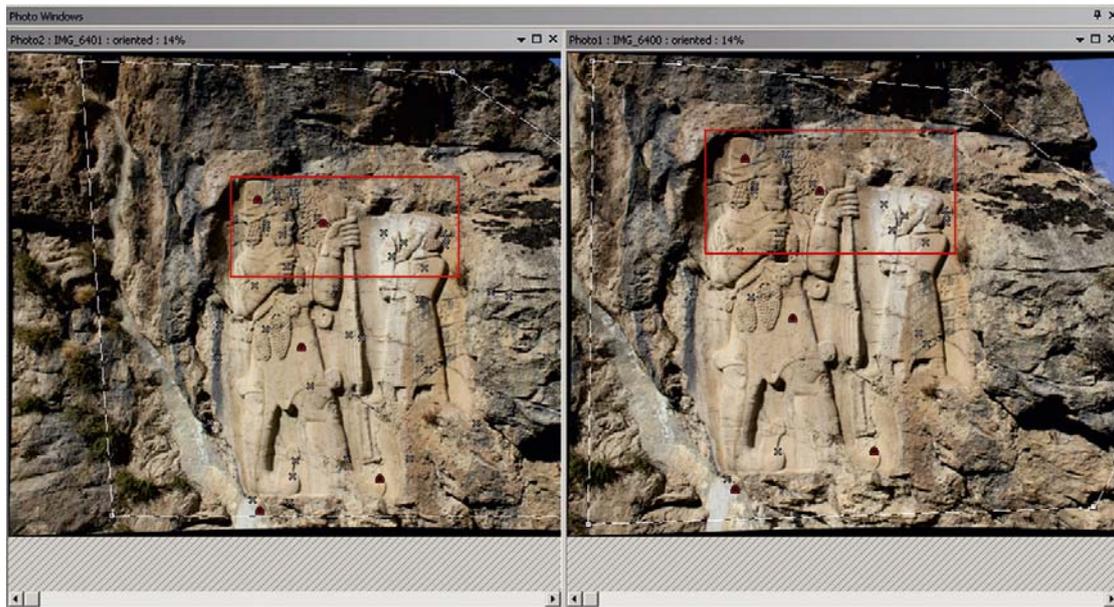


Figure 5: Ground Control Points (red points/spots) and tie points and area of interest (red polygon)

The 3D coordinates of each measured point were determined by spatial intersection, and the standard deviation of each point was shown in the user interface of software for online quality control (Duran and Aydar, 2012).

The project accuracy values with maximum and minimum standard deviations of sixty-seven tie points have been shown in table 2.

Table 2. Project Quality (Unit: meter)

Overall RMS Vector length	0.0156
Maximum Vector length	0.0433
Minimum Vector length	0.0017
Maximum X	0.0265
Maximum Y	0.0283
Maximum Z	0.0198
Minimum X	0.00143
Minimum Y	0.000577
Minimum Z	0.000467

4.3 Point Cloud and 3D Model Generation

Once all of the parameters are in the same reference system, which is defined by the ground control points, dense stereo matching is used to recover the surface of the relief from the stereo pairs (Cabrelles et al., 2010). Photomodeler Scanner provides the tools to create accurate, high-quality 3D models and measurements from photographs. The process is called photo-based 3d scanning (URL.3, Walford, 2010). Normally, the output of the image matching is a dense point cloud of the region of interest. Then, image matching can also be used to determine a depth map (Schouteden et al., 2001).

DSM (Dense surface model) process creates a dense set of points called as point-mesh. While the point-meshes are creating, some parameters should manage for the best surface definition. In this study, two point-meshes created with base to height ratio value 0.14, sampling interval

value 5 mm and matching radius value was 19. If matching radius has a large number, process will be slow but results are being smother and more useful. In this project radius value was 19, as a mean value. Two stereo pairs which have the best angle between photos are chosen. First and second angle is 14.4331, 8.9695 degree respectively. As a result of process, very high point set have been obtained from two point-meshes and totally 2030243 points acquired. Fig. 6 displays the point cloud output that corresponds to the area of interest.

Additionally, the region of interest can be selected to test the speed of matching. Features that are potentially conjugates between images fulfil at least two criteria: the cross-correlation coefficient must be above a predefined threshold, and the distance to the epipolar constraint must be below a predefined threshold (Heipke, 1997).

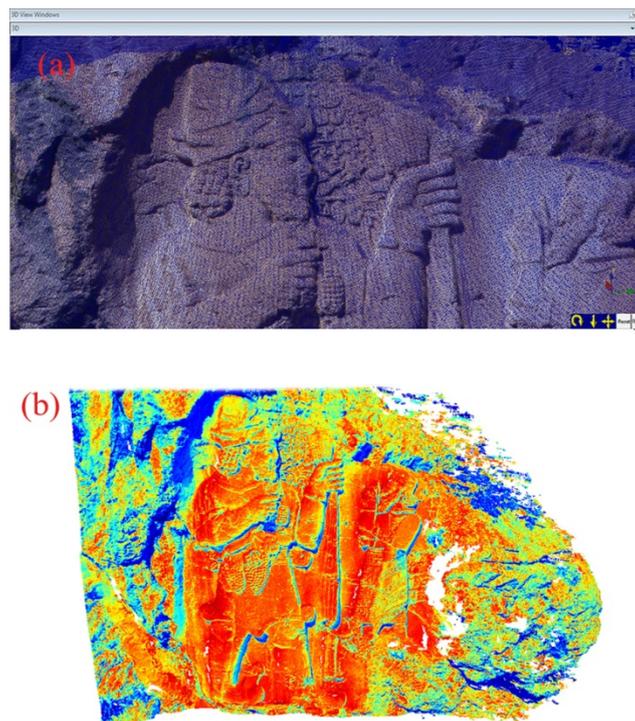


Figure 6:a) Close up of the point cloud of the relief b) Point cloud with colour per vertex (in Meshlab)

The MeshLab software package has been used to visualise more details of the point cloud. Generally, the per-vertex and per-face scalar quantities are used and interchanged by many different algorithms with a variety of different semantics. It is a generic scalar quantity that could be the occlusion value (as is the case here),

a geodesic distance from border, or a Gaussian curvature (URL 2, Meshlab).

A photo-based scanner's accuracy and resolution are affected by the resolution of the camera being used, the distance of the camera to the subject, and the nature of the texture and pattern on the surface (URL.3, Walford, 2010).

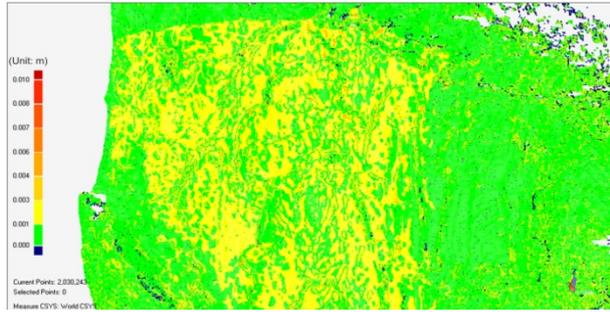


Figure 7: Derivations in multiple stereo-pair point clouds

The 3D scanning process produces a dense point cloud from photographic images or textured surfaces of virtually any size. Different stereo-pairs can be merged, and the derivations and accuracy can be shown in meter unit, as in Fig. 7. When importing huge data sets from file, a coordinate system (CSYS) will be automatically created at the origin of each scan in the file. It makes easy to manage point clouds in software.

Meshing is the next step and was used to cover the entire 3D surface model of the rock Ivriz relief. A triangulated irregular network (TIN) following a Delaunay triangulation was used to cover the relief in the Geomagic Studio software package. Fig. 8 shows the results of the model.



Figure 8: Whole surface model with real texture



Figure 9: a) Close up to the head of the figure on the Ivriz relief b) Wireframe

A 3D photo model is an object model where the texture information is taken from the photographic images (Dorffner and Forkert, 1998). Photo textured models are also known as photorealistic models (Lerma et al., 2010; Cabrelles et al., 2010). Fig. 9 displays a close-up view of the Ivriz models, whereas Fig. 8 shows a general view of the high-resolution 3D photorealistic model.

By using the surface definition tool of Geomagic Studio software, the surfaces were defined, and texture mapping was performed from real images (Fig. 8). The 3D Model of the object can be shown in different colours with shaded views in different software packages, which provides good detail of the surface (Fig. 10).

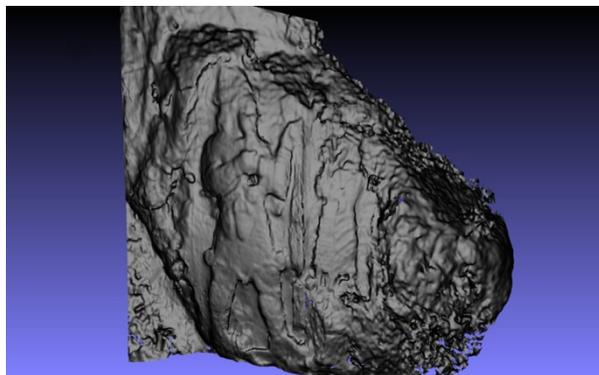


Figure 10: Shaded view of the surface from Meshlab software

Eos Systems' Photomodeler Scanner includes full close-range photogrammetry, point cloud, and geometry definition applications. Sometimes, however, a second programme is required to improve the quality of 3D Models (Schwartz, 2011; Furukawa et al., 2010).

Three-dimensional models allow us to understand the structure and character of spatial objects, even though they are not currently accessible. Using models from existing objects can make it easier to understand complicated structures (Chueca et al., 1996).

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5. DISCUSSION AND CONCLUSION

In this paper, we presented inexpensive photogrammetric techniques to create a 3D reconstruction of the Ivriz relief. The image-based photogrammetric algorithm is acceptable for non-metric digital cameras and produces good quality if multiple overlapping images are taken around the relief. The process requires good estimations for photogrammetric orientation parameters. The results show that highly accurate 3D models can be obtained using conventional cameras (easy-to-use and inexpensive equipment). In addition, high-quality pictures from appropriate positions around the relief were completed. The photogrammetric approach is based on images taken with digital cameras and presents a viable alternative to more expensive approaches and other methods such as distance-based laser scanners. This technique can be effectively used to record archaeological monuments and sites. For these purposes, digital close-range photogrammetry technology was applied to obtain the 3D model of the Ivriz relief. As observed, the relief monument has a complex and non-geometric shape. This situation leads to a poor representation of the surface in 3D modeling, especially for convex sections. However, dense surface modeling provides better representation of this type of surface because they include a high number of points on each area. The light and weather conditions are very important for photogrammetric success, and the colour of the object may affect the data. Because this monument received direct sunlight, the photographs did not have any problems arising from air conditions in the final model. As a result of this study, it is clear that this photogrammetric technique satisfies the requirements of highly precise, 3D monument modeling and archiving. Using this method provides very effective and realistic results.

REFERENCES

- Akca, D. (2012) 3D modelling of cultural heritage objects with a structured light system, *Mediterranean Archaeology and Archaeometry*, vol.12, no 1, 139-152
- Akurgal, E. (1987) *Anadolu uygarliklari*. İstanbul, ISBN 975-479-031-0 (Turkish).
- Arias P., Herraiez, J., Lorenzo H., Ordonez C. (2005) Control of structural problems in cultural heritage monuments using close-range photogrammetry and computer methods. *Computers and Structures* 83: 1754–1766.
- Arias P., Armesto, J., Di-Capua, D., Gonza'lez-Drigo, R., Lorenzo, H., Pe'rez-Gracia V. (2007) Digital photogrammetry, GPR and computational analysis of structural damages in a mediaeval bridge. *Engineering Failure Analysis* 14: 1444–1457.
- Atkinson, K.B. (1996) *Close-range photogrammetry and machine vision*. Whittles Pub., Scotland.
- Barnett, R.D. (1983) From Ivriz to Constantinople: A study in Bird-headed swords. Beiträge zur Altertumskunde Kleinesiens, Festschrift für K. Bittel, (Edited by von R.M. Boehmer-H. Hauptmann), 59-74, Tafel. 11-23.
- Boardman, J. (1984) *The Cambridge Ancient History*. Cambridge University Press. Plates to vol. III
- Bornaz, L. Rinaudo, F. (2004) Terrestrial laser scanner data processing. *XXth ISPRS Congress*, Istanbul, Turkey, 514-519.
- Böhler, W., Heinz, G. (1999) Documentation, surveying, photogrammetry. *XVII CIPA Symposium*, Recife, Olinda. Brazil.
- Cabrelles, M., Seguí, A. E., Navarro, S., Galcerá, S., Portalés, C., Lerma, J. L. (2010) 3D Photorealistic Modelling Of Stone Monuments By Dense Image Matching. *International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences, Vol. XXXVIII, Part 5 Commission V Symposium*, Newcastle upon Tyne, UK.
- Chueca, M., Herraiez, J., Berne, J.L. (1996) Tratado de topografia, Tomo 1. Teoria de errores e instrumentacion. Paraninfo, Madrid, Spain (in Spanish)
- Çelebi, K. (1732) *Cihannuma*. İstanbul, H. 1145, 617.
- Dorffner, L., Forkert, G. (1998) Generation and visualization of 3D photo-models using hybrid block adjustment with assumptions on the object shape. *ISPRS Journal of Photogrammetry & Remote Sensing*, 53(6): 369-378.
- Duran, Z., Aydar, U. (2012) Digital modeling of world's first known length reference unit: The Nipur cubit rod, *Journal of Cultural Heritage*, vol. 13-3, July–September, 352-356, ISSN 1296-2074, 10.1016/j.culher.2011.12.006.
- Furukawa, Y., Curless, B., Seitz, S.M., Szeliski, R. (2010) Towards internet-scale multi-view stereo. *IEEE, Computer Vision and Pattern Recognition (CVPR), 2010 Conference on*, 1434 -1441.
- Georgopoulos, A., G. Ioannidis. (2004) Photogrammetric and surveying methods for the geometric recording of archaeological monuments. *Archaeological Surveys, FIG Working Week Athens, Greece*.
- Grussenmeyer, P., Khalil,O.,A. (2002) Solutions for exterior orientation in photogrammetry: A review. *Journal of The Photogrammetric Record*,17/100, Blackwell Publishing, 1477-9730,10.1111/j.1477-9730.2002.tb01907.x,615--634
- Hawkins, J.D. (2000) *Inscriptions of the Iron Age, Corpus of Hieroglyphic Luwian*. The University of Chicago Press, vol. I, Berlin, New York, 10.1086/380348
- Heipke, C. (1997) Automation of interior, relative, and absolute orientation. *ISPRS Journal of Photogrammetry and Remote Sensing*, 52, 1-19.
- Karauğuz, G. (2006) Ivriz kaya anitlari ve çevresi üzerine bir araştırma. *Arkeoloji ve Sanat*, XXII, 23-50 (Turkish).
- Karauğuz, G., Çorumluoğlu, Ö., Kalaycı, İ., Asri, İ. (2009) 3D Photogrammetric model of Eflatunpınar monument at the age of Hittite empire in Anatolia. *Journal of Cultural Heritage*, 10, 269-274.

- Kraus, K. (2000) *Photogrammetry Fundamentals and Standard Processes*. vol. 1, Dümmlers Pub, Köln, Germany.
- Kulur, S., Yilmazturk, F. (2005) 3D reconstruction of small historical objects to exhibit in virtual museum by means of digital photogrammetry. *CIPA XX. International Symposium, International Cooperation to Save the World's Cultural Heritage, 26 September-01 October, Torino, Italy*. Available online at <http://cipa.icomos.org/fileadmin/template/doc/TURIN/409.pdf>
- Lerma, J. L., Navarro, S., Cabrelles, M., Villaverde, V. (2010) Terrestrial laser scanning and close-range photogrammetry for 3D archaeological documentation: the upper palaeolithic cave of Parpalló as a case study. *Journal of Archeological Science*, 37(3): 499-507.
- Letellier, R., Werner S., François LeBlanc (2007) Recording, documentation and information management for the conservation of heritage places: Guiding principles. Los Angeles, The Getty Conservation Institute, pp 174. Available as PDF file from: http://www.getty.edu/conservation/publications/pdf_publications/recordim.html
- Messerchmidt, L. (1906) *Corpus Inscriptionum Hettiticarum*, II. (MVAeG XI, 5), Berlin, Available online at <http://www.britannica.com/EBchecked/topic/138525/Corpus-Inscriptionum-Hettiticarum>
- Nuttens, T., Wulf, D. A., Bral, L., Wit, D. B., Carlier, L., Ryck, D. M., Stal, C., Constales, D., Backer, D. H. (2010) High Resolution Terrestrial Laser Scanning for Tunnel Deformation Measurements. *FIG Congress Facing the Challenges – Building the Capacity*, Sydney, Australia.
- Peipe, J., Tecklenburg, W. (2006) Photogrammetric camera calibration software - a comparison. *ISPRS Symposium XXXVI*, Page(s) 4, Dresden, Germany.
- Scherer, M. (2002) About the synthesis of different methods in surveying, *XVIII International Symposium of CIPA*, Potsdam, Germany.
- Schouteden, J., Pollefeys M., Vergauwen M., Van Gool, L. (2001) Image-based 3D acquisition tool for architectural conservation. *Proceedings of the XVIII International Symposium of CIPA, ISPRS International Archive of Photogrammetry, Remote Sensing and Spatial Information Sciences Vol. 34, Part 5/C7*, 301-305.
- Schwartz, J. M. (2011) Precise positioning surveillance in 3-D using night-vision stereoscopic photogrammetry, Display Technologies and Applications for Defense. *Security and Avionics V. and Enhanced and Synthetic Vision 2011*, 80420A.
- Sienz, J., Szarvasy I., Hinton E., Andrade M.L. (2000) Computational modeling of 3D objects by using fitting techniques and subsequent mesh generation. *Computers and Structures* 78, 397–413.
- Toz, G., Duran, Z. (2004) Documentation and Analysis of Cultural Heritage By Photogrammetric Methods and GIS: A Case Study. *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Vol XXXV, Part B5, July 12-23, Istanbul*. Available online at <http://www.isprs.org/proceedings/XXXV/congress/comm5/papers/593.pdf>

Web References

- Url.1, KTB (2010) Kültür ve Turizm Bakanlığı, www.kultur.gov.tr/ (Turkish).
- Url.2, Meshlab, <http://meshlab.sourceforge.net/>.
- Url.3, Walford, A. (2010) A new Way to 3D Scan, White Paper, Photomodeler Eos System, <http://photomodeler.com>.