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Review Paper

Drawing of petroglyphs in Mongolia by close range photogrammetry

C. Alyilmaz[1], M. Yakar[2]* and H. Murat Yilmaz[3]

[1]Atatürk University, Department of Education Faculty, Erzurum Turkey.
[2]Selcuk University, Engineering Faculty, Department of Geodesy and Photogrammetry, 42230 Konya/Turkey.
[3]Aksaray University, Engineering Faculty, Department of Geodesy and Photogrammetry, 68100 Aksaray/Turkey.

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Petroglyphs are images created by removing part of a rock surfaces by incising, pecking, carving, and abrading. The word comes from the Greek words petros meaning "stone" and glyphein meaning "to carve" (it was originally coined in French as pétroglyphe). Carved, forged or engraved petroglyhps are tarnsforming the sights ,which is placed on the area, to the natural museums. According to experts, petroglyhps are qualifying "expression resource", "mass medium" even "writings" of the times which is created date. In the portraits which are showing the praise god and complete dedication ,generally, shamans, khans, comanders have placed on the top. Besides all religion themed and ritual petroglyhps , there are also a very kind of petroglyhps which are treated everyday lifes, hunting, war scenes and ordinary events. There are several documentation techniques available in order to document of cultural heritage. These techniques are indispensable tools for the conservation of heritage monuments. These methods and equipments commonly are used for the documentation and surveying of buildings. Digital close range photogrammetry is one of the most important methods in documenting of cultural heritage.

Key words: Petroglyphs, Mongolia, close range photogrammetry, documenting.

INTRODUCTION

Heritage and culture are two important components in life of societies. Monuments and monumental groups are constructions of great value, because they represent the history and memory of the communities where they are placed (Pegon et al., 2001). Many features of cultural heritage may be classified as public goods, and despite the fact that there are insufficient public resources to guarantee their maintenance and preservation, cultural and heritage goods provide certain benefits and externalities to the areas in which they are located (Bedate et al., 2004). Culture (and related activities) not only creates significant economic flows, but may also be used as a means of transforming certain geographic areas, and therefore, forms part of many local and regional economic development strategies (Dziembowska, 2000; Herrero, 1997; Slama, 1980).

UNESCO (1946) and the Council of Europe have formed specialized organizations for this goal. ICOMOS (International Council for Monuments and Sites) is the most important one, but also CIPA (International Committee for Architectural Photogrammetry), ISPRS (International Society for Photogrammetry and Remote Sensing), ICOM (International Council for Museums), ICCROM (International Centre for the Conservation and Restoration of Monuments) and UIA (International Union of Architects) are all involved in this task.

The documentation of a cultural heritage may be defined as (Georgopoulos and Ioannidis, 2004); The action of acquiring, processing, presenting and recording the necessary data for the determination of the position and the actual existing form, shape and size of a monument in the three dimensional space at a particular given moment in time.

There are several documentation techniques available (Böhler, 1999). Such techniques are indispensable tools for the conservation of heritage monuments. The conver-

*Corresponding author. E-mail: murat.yakar.konya@gmail.com.

vation has to be carried out prior to the buildings destruction, transformation or undertaking of any intervention. These methods are envisaged to provide the building with a coordinates system (X,Y,Z) (Pieraccini et al., 2001). These methods and equipments commonly used for the documentation and surveying of buildings are (Scherer, 2002): traditional manual methods, topographic methods, photogrammetric methods and scanning methods.

TRADITIONAL MANUAL METHODS

The equipment used is very simple (tape measure, plumbs, manual laser distance measurement). Some information is lost in the transmission of data from the original to the theoretic model. This reduction–addition process is unintentional (Weferling, 2002). Massive utilization of these methods is justified because of economic causes and lack of necessary formation. (Nickerson, 1994) estimates the degree of precision obtained in some works carried out with traditional manual methods, whose values are compared in several cases.

Free hand drawing or sketching is simple and easy to conduct in the field but provides only a two-dimensional record and is generally inaccurate (Brayer et al., 1998).

TOPOGRAPHIC METHODS

The equipment used are tachometers and/or total stations. When the point to be determined is inaccessible (upper parts of facades, cornices, etc.) indirect methods are used (intersection). For further information see (Chueca and Herraez, 1996). New developments have been incorpora-ted into laser total stations, such as the measurement of distances without reflector element by means of laser rays. This technology is suitable for documentation works. Thus, when distances are not too large direct contact is not needed to locate the object-points.

CLOSE RANGE PHOTOGRAMMETRIC METHODS

The short duration of field work measuring time is a remarkable feature of photogrammetry. Photogrammetric works are normally performed without any contact with the object. For further information see Kraus v.1 and v.2 . Phototgrammetric method is more accurate, faster , more economic and more reliable than other documentation techniques.

The final result can be registered in the ‘‘construction photogrammetric files’’. These files are of great importance because they hold all the information needed to make any measurement or plan when required, either immediately subsequent to the surveying or later. The files assure the ‘‘intellectual conservation’’ of the object in its real state at a precise moment of its history (Arias et al., 2005).

LASER SCANNING METHODS

Laser scanners can potentially provide complete and accurate representation of highly irregular surfaces. Combined with color information, either from the scanner itself or from a digital camera, a realistic-looking model can be created. Ideally the scanner should be tailor made to the specific requirement of the application. The accuracy at the given range and the capture of both geometry and reflection or intensity are key scanner properties. Also due to size, geometric configurations, and occlusions, it is usually necessary to use multiple scans from different locations to cover the entire scene. Aligning and integrating the different scans, for which many techniques are available, will also affect the final accuracy of the 3-D model.

The documentation records the present of cultural heritage, as this has been shaped in the course of time and is the necessary background for the studies of their past, as well as the studies for their future. Documentation should be considered as an integral part of a greater action in general documentation of the cultural heritage. This comprises, among others, the historical documentation, the architectural documentation, the bibliographic documentation etc (Georgopoulos and Ioannidis, 2004). Cultural herit-age protection is a key issue around the world today. The increase in public awareness over recent years that these kinds of monuments constitute an important part of our past (Salazarand Marques, 2005).

The effective documentation and display of ancient artifacts and antiquities is an essential task in the field of cultural heritage conservation. Traditional methods are slow, time-consuming and present a number of evident limitations. A digital archive of high quality three-dimensional models would constitute a great improvement in this field. Digital archives are durable and unalterable, and thus can be used as reference for degradation monitoring and restoration of Works (Pieraccini et al., 2001).

Today, the 3D reconstruction and visualization techniques became very popular and useful methods in the field of digital close range photogrammetry. 3D drawing and save different format has become widespread using of 3D reconstruction and visualization. The other advantage of techniques, the object has been visualization at different point of view. 3D modeling and visualization of historical objects are very sophisticated and complex procedures in the job of documentation of cultural heritage (Kulur and Yilmazturk, 2005). Digital close range photogrammetry is a very effective and useful in documentation on cultural heritage. Work in this like is one of the most important applications of digital close range photogrammetry. Digital photogrammetric systems allow

Figure 1. Typical a petroglyph from Mongolia.

the use of conventional digital cameras and consequently lower costs (about 600 €) (Gruen, 2001).

PETROGHYLIPY AS A HISTORICAL AND CULTURAL HERITAGE

Petroglyphs are images created by removing part of a rock surfaces by incising, pecking, carving, and abrading. The oldest petroglyphs are dated to approximately the Neolithic and late Upper Paleolithic boundary, about 10,000 - 12,000 years ago, if not earlier (Kamyana Mohyla). Around 7,000 - 9,000 years ago, other precursors of writing systems, such as pictographs and ideograms, began to appear.

Petroglyphs were still common though, and some cultures continued using them much longer, even until contact with Western culture was made in the 20th century. Petroglyphs have been found in all parts of the globe except Antarctica with highest concentrations in parts of Africa, Scandinavia, Siberia, southwestern North America and Australia.

There are many theories to explain their purpose, depending on their location, age, and the type of image. Some petroglyphs are thought to be astronomical markers, maps, and other forms of symbolic communication, including a form of "pre-writing". They might also have been a by-product of other rituals: sites in India, for example, have been identified as musical instruments or "rock gongs".

Some petroglyph images probably had deep cultural and religious significance for the societies that created them; in many cases this significance remains for their descendants. Many petroglyphs are thought to represent some kind of not-yet-fully understood symbolic or ritual language URL1.

Some researchers have noticed the resemblance of different styles of petroglyphs across different continents; while it is expected that all people would be inspired by their surroundings, it is harder to explain the common styles. This could be mere coincidence, an indication that certain groups of people migrated widely from some initial common area, or indication of a common origin (Sundstrom, 2004; Chakravarty and Bennarik, 1997).

A twofold classification is often used to differentiate between the additive and subtractive forms of creating images on rock surfaces (Rosenfeld, 1988). The additive form generally involves the painting of natural sediments, generally referred to as “pictographs” (Rosenfeld, 1988). The subtractive form involves the removal of material in an engraving procedure creating “petroglyphs” (Figure 1). Engraved rock art is common throughout Australia and many of the sites visited by the authors consisted of simple figurative representations such as animals (Figure 1). Anthropologist do not fully understand why engravings were made but it is evident that abori-gines originally lived close to and were totally dependent upon the land (Stanbury and Clegg, 1990).

The rock engravings were used to pass on tribal knowledge and although the spoken word was crucial; song, dance, ritual and pictures were of equal significance in passing on folklore down through the generations. Aboriginal communities place great symbolic significance to their links with the past, which is visibly reflected in rock art sites (Rosenfeld, 1988). Engravings are not only valuable for aesthetic and scientific reasons, but also they represent a direct line to their ancestors and the land. (Stanbury and Clegg, 1990)

DIGITAL CLOSE RANGE PHOTOGRAMMETRY

Digital Close range photogrammetry measures objects directly from photographs or digital images captured with a camera at close range (Bedate et al., 2004; Böhler and Heinz, 1999). The basic model in digital close range photogrammetry is the central perspective projection. The primary coordinate system is positioned arbitrarily in object space, while the secondary system as its origin at the perspective camera center *O*, its z-axis coincides with the principal axis and is directed away from the projection (image) plane (Figure 2). The scale factor is set to unity (Atkinson, 1996; Arias et al., 2007).

In the primary system we have the coordinates of the perspective center, *O*, and an object point in space, *A*: (X_0,Y_0,Z_0) and (X_A,Y_A,Z_A), respectively. The projection of *A*, through *O*, in the image plane, expressed in the secondary system, give the coordinates of point *a*: $(x_a,y_a,-c)$, where "*c*" is the principal distance (sometimes called effective focal length), between *O* and the principal point, *PP*. Points *A* and *a* are called homologous. Thus, we have: $X_A = X_0 + (-\mu)R^t x_a$, where μ is a positive scalar quantity proportional to the object distance from *A* to *O*.

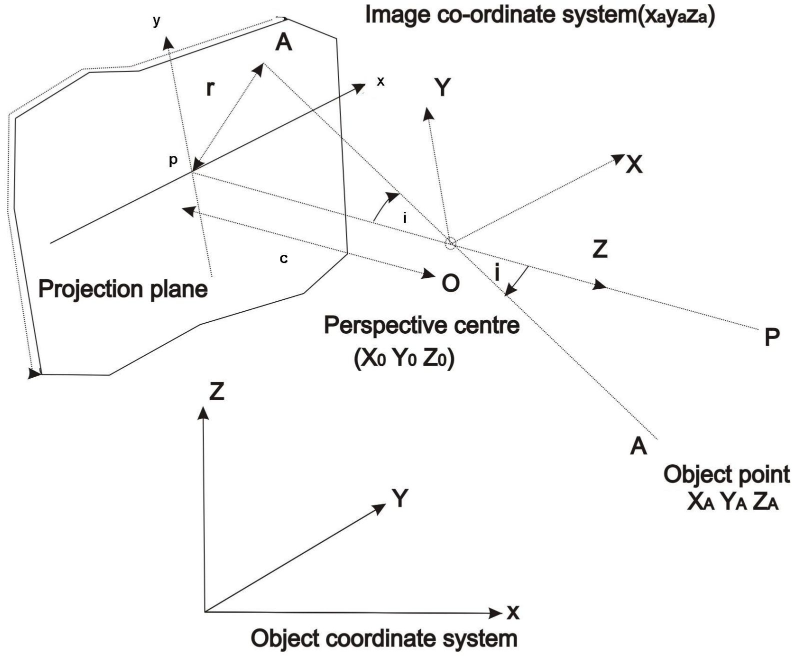

Figure 2. The central perspective projection.

The reverse transform is then given as:

$$\begin{bmatrix} x_a \\ y_a \\ -c \end{bmatrix} = \mu^{-1} \begin{bmatrix} r_{11} & r_{21} & r_{31} \\ r_{12} & r_{22} & r_{32} \\ r_{13} & r_{23} & r_{33} \end{bmatrix} \begin{bmatrix} X_A - X_0 \\ Y_A - Y_0 \\ Z_A - Z_0 \end{bmatrix} \quad (1)$$

Note that the vectors (X_A-X_0), x_a are collinear but of opposite sense.

The 3rd equation of the reverse transform above can be written explicity in terms of the scaling μ and substituted in the other 2 equations, leading to the Collinearity equations:

$$x_a = \frac{-c[r_{11}(X_0 - X_A) + r_{12}(Y_0 - Y_A) + r_{13}(Z_0 - Z_A)]}{[r_{31}(X_0 - X_A) + r_{32}(Y_0 - Y_A) + r_{33}(Z_0 - Z_A)]}$$

and

$$y_a = \frac{-c[r_{21}(X_0 - X_A) + r_{22}(Y_0 - Y_A) + r_{23}(Z_0 - Z_A)]}{[r_{31}(X_0 - X_A) + r_{32}(Y_0 - Y_A) + r_{33}(Z_0 - Z_A)]} \quad (2)$$

Camera calibration - ınterior parameters

The central perspective projection model is only an idealization (and simplification) of the actual optical geometry commonly found in cameras. Camera calibration is concerned with identifying how much the geometry of image formation differs in a real camera.

Resection - exterior parameters

Once the interior (calibration) parameters are known, their remains 6 exterior orientations parameters to determine (3D translation and rotation). This evaluation is called resection. At least 3 non-collinear targets such as point A above, called control points are needed.

When more than 3 control points are available, a more rigorous statistical approach can be used. E.g. the collinearity equations above can be linearized and a LSE (Least Square Estimation) used. Good initial values are required however, for the LSE process to converge to appropriate values (Atkinson, 1996; Arias et al., 2007). Having an object point *A* and two homologues *a1* and *a2*, projected in 2 images assumed calibrated and resected, the collinearity equations are used to retrieve the 3D space coordinates of *A*, a process called intersection (Figure 3). The problem is over-constrained; having 4 equations and 3 unknowns, and LSE can be used again.

Coplanarity equation

Relative orientation is the evaluation of the exterior orientation elements of one camera w/r to the photo coordinate system of another camera.

Consider once again the target *A* with images at a_1 and a_2. Then the vectors:

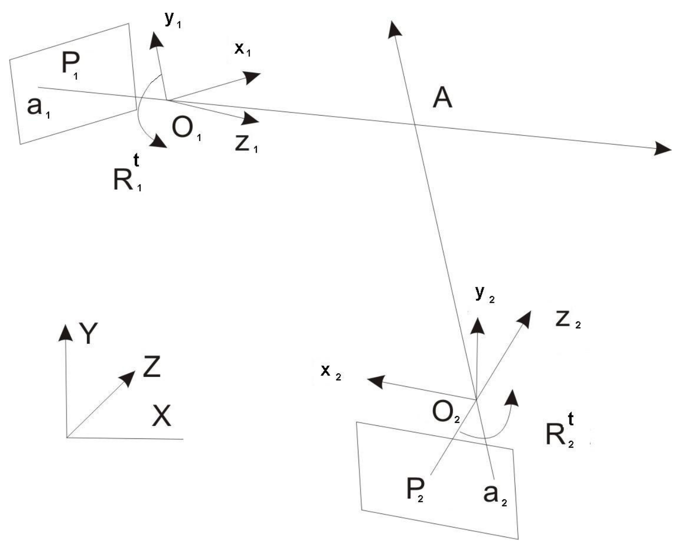

Figure 3. Intersection.

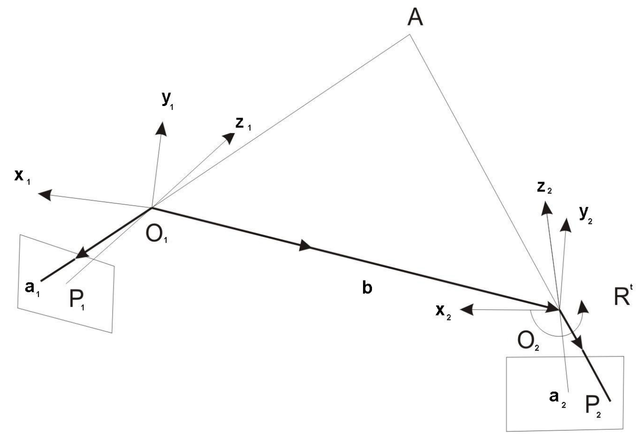

Figure 4. Coplanarity.

$$\boldsymbol{a}_1 = (-\lambda)[x_1 y_1 (-c_1)]^t, \quad \boldsymbol{a}_2 = (-\mu \boldsymbol{R}^t)[x_2 y_2 (-c_2)]^t, \quad \boldsymbol{b} = [b_x b_y b_z]^t \tag{3}$$

Are coplanar, where *b* is the camera base (of the stereo pair). They lie in the epipolar plane of *A* and the 2 perspective centers (Figure 4).

Assuming that the base vector is non-zero and using $\boldsymbol{R}^t \boldsymbol{a}_2 = \boldsymbol{a}'_2 = [x'_2 y'_2 z'_2]^t$ we get the coplanarity equation for target *A*:

$$det \begin{bmatrix} 1 & x_1 & x'_2 \\ \frac{b_y}{b_x} & y_1 & y'_2 \\ \frac{b_z}{b_x} & -c_1 & z'_2 \end{bmatrix} = 0 \tag{4}$$

At least 3 targets are necessary (i.e., 6 constraints or coordinates) to determine the 5 elements of relative orientation: $(b_y/b_x, b_z/b_x, \omega, \varphi, \kappa)$.

After relative orientation has been performed, we can use the measured photo-coordinates of the 2 homologues of a target in order to evaluate, by intersection, its coordinates relative to the (x_1,y_1,z_1) axes. Such coordinates are called model coordinates (Atkinson, 1996; Arias et al., 2007; Cooper and Robson, 1996).

When compared to traditional surveying methods, digital close range photogrammetry is efficient and rapid, significantly reducing the time required to collect data in the field. Measurements collected in less than three days in the field would have taken 10 days in a conventional survey. This method is considerably safer. All surveyors can obtain precise measurements without physically accessing each measurement point. Finally, the process produced a comprehensive visual record of existing site conditions from which any identifiable features can be measured or geometrically assessed at a later date. Digital close range photogrammetric measurements can be integrated with 3D modeling and reverse engineering processes. The acquired data is infinite and the cost savings substantial. One of the main features of photogrammetric methods is the short length of time required on-site to carry out measurements.

Digital Close Range Photogrammetric methods have been successfully applied to projects in archaeology, architecture, automotive and aerospace engineering, and accident reconstruction (Atkinson, 1996; Cooper et al., 1996; Kraus, 1993; Wolf, 1991).

It is defined that in a research in Austria with the equal number of worker is done and all measurements are taken in traditional and also in photogrammetric method. And at the end of the research, it is concluded that photogrammetric method is more efficient than conventional methods 100-130 times, 2-5 times in graphically, and also accuracy 10 times
more than traditional methods (Sagiroglu, 2004).

PETROGHYLIPYS IN MONGOLIA

When we hear about the Mongolian People's Republic we immediately think about the ancient Turkic inscriptions (especially about Kol Tigin, Bilge Kagan and Bilge Tonyukuk inscriptions). A lot of cultural inheritance existing in history is saved in the places where the ancient inscriptions are settled. Because there were located a lot of inscriptions such as Saka, Hun, Avar, Kokturk, Uygur, gravestones, burial mounds, graves, populated areas, sculpture, balbal, jewelry and other valuable things.

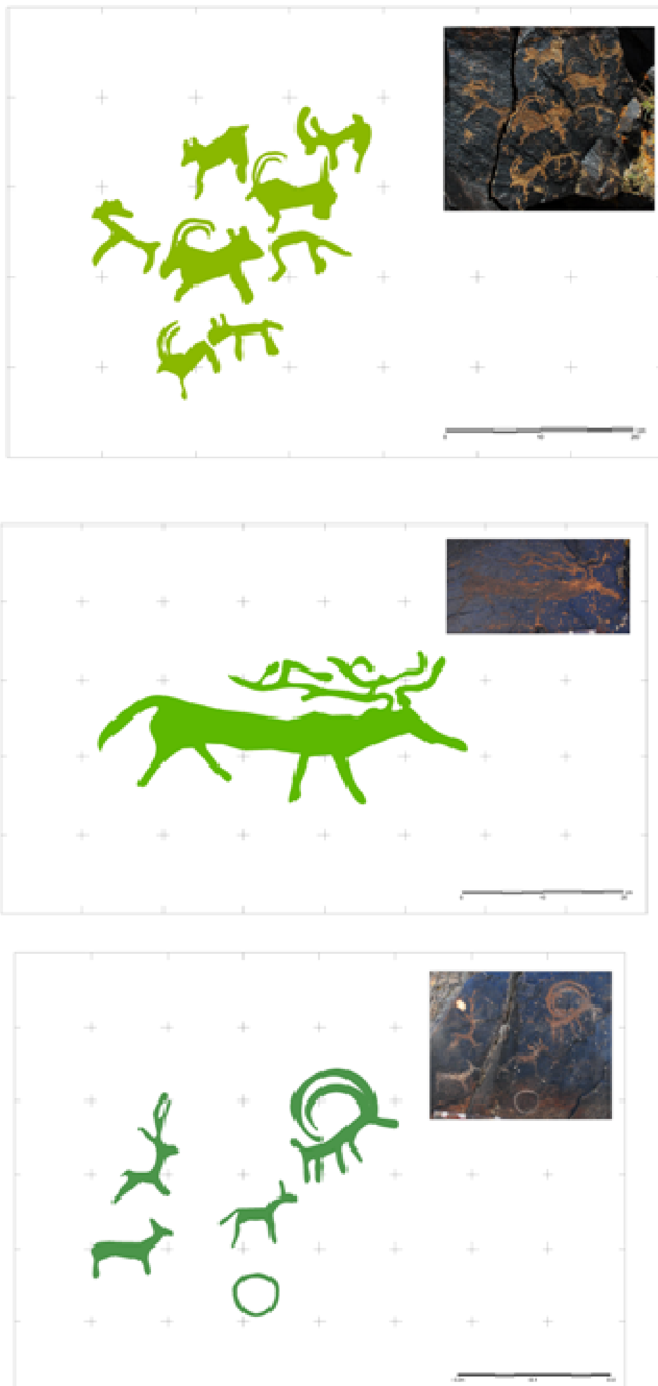

Figure 5. Drawings of petroglyphs.

In Mongolian Republic one can find the petrogliphes are served as a living picture and source of communication which turn these places into museum in the open air.

The petrogliphes in the mountains and rocks that located in these territories Hövsgöl Aymag, Uvs Aymag, Ömnögov Aymag, Bulgan Aymag, Suhbatar Aymag, Govi-Altay Aymag, Töv Aymag, Arhangay Aymag, Bayan Ölgey Aymag, Dund-Govi Aymag include the names of places connected with this territory, names of mountains, rocks, populated areas such as Suman Gol, Çullut Gol, Şivertiyn Am, Har Yamaa, Tsagaan Salaa, Hötöl Ötög, Üüdent, Övgönt, Baruun Mogoy, Baruun Tsahir, Tüvd, Paaluu, Morin Tolgoy, Terem, Gurvan Tolgoy, Mojoo, Bujaa, Şovgor Had, İh Sar, Tuşaat, Hamuut, Har Höndiyn Naran, Alag Çuluu, Çambagarva, Raşaant Tsahir, Zuun Tsahir, Sevrey, Modtoy Tolgoy, Buyantın Ereg, Hangiday, Höröögiin Üzüüriin, Baga Oygor, Baruun Bilüünii Eh.

The petrogliphes saved for thousand years a lot of meaningful information not only about Turkic tribe's civilization and culture, view points relatively world, aesthetic taste, their mode of life and beliefs but also historical and geographical features of these places, animals which lived in these period as well as the nature. The petrogliphes which concerning Turkic civilization basically express connection between person and nature and universe through graphical sources.

When the Turkic people describe through graphical sources connection between person and god as well as sacred animal they take the pictures of heavenly body (sun, moon) and animals (deer, mountain goats, wolfs, eagles, sneeze).

PHOTOGRAMMETRIC EVALUATIONS

Calibration of the cameras was carried out in the office. This calibration is usually carried out through the analysis of the views of a test object (calibration target-set), which usually consists of a set of fiducial marks (targets), positioned within the 3D volume that is being imaged by the camera system. If the geometrical characteristics of this target-set are only partially known or completely unknown, then the calibration process must include the refinement or the blind estimation of the 3D coordinates of the targets The calculated camera parameters of the Nikon d200 digital camera were as follows;

Focal length = 20, 8090 distortion parameters are k1 = 1,269.10 - 3, k2 = 1,860.10 - 5 p1 = -4,203.10 - 5 p2 = 1,722.10 - 5

All photographs, measured coordinate values and camera calibration parameters were transferred to photomodeler software and drawing of the object completed. All details have been transferred to dxf file (Figure 5)

CONCLUSİON

Aboriginal rock art has an important position in the cultural heritage of the world. Cultural Heritage preservation and access is an important goal for cultural heritages Petroglyhps are among the most important cultural heritages. These culturel heritages are located very far from the centre of the villages, and cities. Some of them can be reached about one week expedition. Working is very dangeres and hard at the monuments area. So , some times it is needed very fast and short time to study on the site. For this reason; quick and modern Technologies are needed for these types of studies. Digital close range photogrammetry is among these modern documentation technologies.

In this study we have presented a digitization system that combines Close range photogrammetry technology in a way that provides good results for the petroglyphs. An efficient and effective method of recording petroglyphs and pictographs using digital photogrammetry has been presented. The approach takes advantage of the new range of cheap digital cameras, which if calibrated can produce accurate 3D data. Appropriate photogrammetric software is capable of obtaining of all types 3d data . In this study; drawing and 3D d modelling of the mongolian petroglyphs have been completed.

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