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The high official Harkhuf and the inscriptions of his tomb in Aswan (Egypt). An integrated methodological approach

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ABSTRACT
TECH project (Technology for the Egyptian Cultural Heritage) aimed to document an Egyptian monument for Egyptological studies and researches but, at the same time, to check a new methodological approach for conservation, valorisation and enhancement. In particular, the CNR mission focused the attention on the tomb of Harkhuf, a high official of the VI dynasty (XXIII century BC), who led trading and military expeditions into Nubia. The hieroglyphic texts inscribed on the façade of his tomb are very important and famous documents. The team checked an innovative and integrated methodology. The methodology has been focused mainly on the use of digital photogrammetric systems in order to generate an accurate numerical model (3D) and to facilitate the epigraphic study. Different procedures have been established in the processing and representation steps in order to accomplish the final communication of the results. Moreover climatic measurements have been carried out in order to understand the role of environmental factors on the deterioration of the monument. Finally the data have been crossed in order to check the environmental impact and the decay.

Section: RESEARCH PAPER

Keywords: Harkhuf Tomb; Epigraphic Numerical Model; Image Based 3D model; Virtual Scan; Aswan Climate

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1. INTRODUCTION TO THE PROJECT

The CNR – Multidisciplinary Egyptological Mission (CNR – MEM) has worked in the tomb of Harkhuf in order to document its important hieroglyphic inscriptions. The mission has been carried out in the framework of the project TECH (Technologies for the Egyptian Cultural Heritage) funded by the National Research Council of Italy (CNR) and the Academy of Scientific Research and Technology of Egypt (ASRT).

Aswan is the southern gate of Egypt: in ancient times caravan routes left the Nile Valley from this site to reach far away territories and different populations, carrying back exotic and precious goods.

The ancient city of Elephantine, the river island in the modern town of Aswan, was the gateway to Africa, the bridgehead towards unknown lands as dangerous as rich in exotic treasures.

Between the late Old Kingdom and the early Middle Kingdom, the tombs of the nobles at Qubbet el-Hawa testify of ancient journeys, far south explorations, trades and cultural exchanges, in particular, the tomb of Harkhuf, a high official of the VI dynasty, who led trading and military expeditions into Nubia [1]. The text inscribed on the façade of his tomb is a very important and famous document (Figure 1).

Harkhuf led at least four expeditions to far away countries in the southern or west-southern territories. His tomb testifies of his life, his career, his journeys and explorations towards south, in the Nubia and in the Lybian desert. Harkhuf was a noble of Upper Egypt, he served the kings Merenra and Pepi II, during the VI dynasty in the XXIII cent. BC [1].

This tomb was at first noticed by an Italian scholar, Ernesto

Figure 1. The famous Tomb of Harkhuf in Aswan, Egypt. The tomb was completely carved out in the stone.

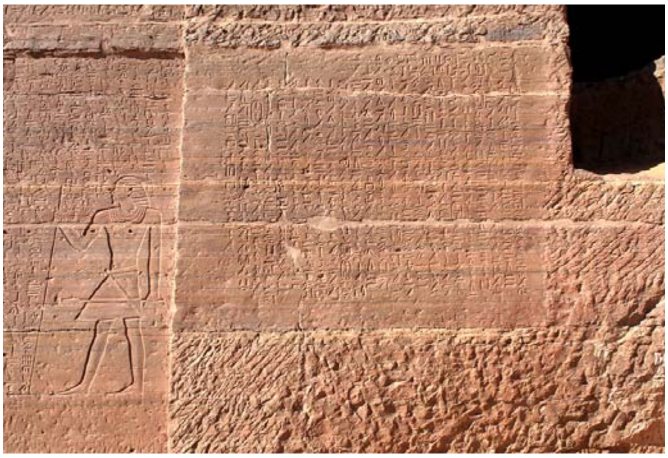


Figure 2. One of the inscription preserved on the main façade of the tomb. In particular it represents an important document of Harkhuf's life.

Schiaparelli, famous Egyptologist who discovered f.i. the tomb of Nefertary and other important monuments. Schiaparelli, who was Director of the Egyptian Museum in Florence and of the Egyptian Museum of Turin, published the inscriptions in the Memorie dell'Accademia dei Lincei in 1892 [2]. Schiaparelli was a pioneer of the inter-disciplinary Archaeology and Egyptology, and he used the photography as an instrument for documentation on the archaeological field.

In 1975, Miriam Lichtheim, who published a famous work on Ancient Egyptian Literature, wrote in her book: Cut in soft, flaking stone, the inscription (of Harkhuf) is now in a very poor condition. In fact, the wind, the sun and some rainfalls contribute to the decay [3].

TECH project aimed to check a non-invasive methodology for documenting Egyptian monuments and above all Egyptian epigraphy. The tomb of Harkhuf has been chosen because of its importance, its status and for the old documentation provided by E. Schiaparelli, which represented the starting point for the work.

The project aimed at a very good documentation using digital photogrammetric system in order to obtain data on its conditions, to check the decay and the influence of the environmental factors.

2. THE ACQUISITION STEP OF THE INSCRIPTIONS

2.1. Introduction to the survey

The work presented in the paper is a preliminary note of a wider project on the Tomb of Harkhuf. Since the first survey on the site, in 2014, several and damaged inscriptions preserved on the façade and the pillars inside the tomb, have been noticed. Most of them are in different conditions, probably due to the intrinsic characteristics of the stones and to the weathering phenomenon. From the observations made during the mission emerged the importance of documenting the inscriptions, that actually risk to be lost forever. The most important inscriptions are visible on the main façade. They represent an important document of the Harkhuf's life (Figure 2). The four pillars inside show reliefs and inscriptions with funerary formulas.

The first step of the work was the documentation of the existing texts with a methodology that was able to record the signs and, at the same time, was able to evidence the differential degradation. Every inscription was accurately documented through the use of photogrammetric systems. Image based 3D methods can be considered a valid instrument of investigation and analysis to improve the knowledge in the archaeological field [4]. In recent years the development of digital photogrammetric systems allowed to define a very accurate working procedure of data acquisition and processing in the archaeological discipline. The extraordinary development of camera sensors, the manufacturing of the lenses and the more accurate algorithms for the recognition of the homologous points on images, allow to reconstruct the whole investigated subject [5].

The methodology was focused on the use of photogrammetric system despite other different approaches for the investigation could be used, such as the laser scanner (triangulation/phase difference) [6] or more recently, polynomial texture mapping (PTM) [7]. This second system is able to display depth details of an object, interpolating information carried out from different lighting of the surface. The limits of PTM consist in a not scaled model, the reduced size of the subject that cannot exceed the meter and the difficulty to apply the system in an open space.

The use of digital photogrammetry was justified by the possibility to use a simple device (such as a camera) in almost every condition, collecting important information and data about archaeological artefacts. Furthermore, due to the history and evolution of the photogrammetry, it is possible to evaluate its potentiality and extension to different application fields [8].

2.2. The experimentation on the Tomb of Harkhuf

The first step of the research focused mainly on the external façades subjected to a greater stress. The survey was performed using two reflex cameras (Canon 5D Mark II, Canon 60D) with different optic lenses (Canon 28 mm/50 mm). The following modalities have been used:

- Structure from Motion (SfM/Agisoft Photoscan);
- Stereoscopic digital photogrammetry (Mencisoftware Z-Scan.

The first system allows to perform photogrammetric acquisition, starting from unordered images. The software used is a commercial package able to orient and match large dataset of images.

There is no published information concerning the matching algorithms employed in the software, even if it seems to be a stereo SGM-method [9].

In order to achieve accurate data, it is important to acquire images according to an established procedure. The algorithms used from the software are mainly based on the automatic recognition of the homologous points. The geometrical model is well known as epipolar geometry (Figure 3).

This particular geometry is able to establish a relation between a couple of images. Consider two different frames and a point P in the space. The point P generates two homologous projections on the corresponding frames. We define on the frame the corresponding images of the projection centres (epipoles or epipolar points), in order to create the adequate relation. The epipolar plane is identified from the base and the collineation lines. The intersections between the epipolar plane and the two image planes are called epipolar lines. On the epipolar lines it is possible to find the image of the homologous point of the other frame.

Recent studies on this geometry demonstrated how the correspondences between features can be improved as a function of the position of the frames [10]. Normally the epipoles are casually displaced on the frames. Their position is much more far from the principal point as the optical axis is parallel. In that condition, when the frames are coplanar, the epipolar lines are in parallel. This is the best condition for the software to recognize the homologous points. The advantage consists in a lesser processing time and a more accurate point clouds (less noises).

On the field a 28 mm optic lens with a tripod mounted at 0.50 m from the façade were used, moving the camera along the entire surface (Figure 4). The acquisition simulated imaginary tracks in a bustrophedic direction (tape method). They were taken more than 400 pictures only for the letter of Harkhuf at very high resolution and with 80 % of overlapping among the pictures. The side lap between each photographic sequence was about 30 %. The choice of the 28 mm optic lens guaranteed a good compromise between radial distortion and the covered area. Experimentations were performed also with the other camera in the same condition, to test differences between the camera sensors. Canon 5D Mark II is provided with a full frame sensor while Canon 60D is equipped with an APS-C sensor. This difference conditioned the number of acquisitions on the face of the tomb. Positioning the second camera at the same distance from the subject we needed more images to compensate the overlapping area.

Figure 4. Acquisition step performed with a Canon 5D Mark II and Canon 60D mounted on a tripod half a meter from the surface.

The second experimentation was performed with the other system (*stereomatching*), based on the stereoscopic acquisition of three images, using the same cameras. The Canon 5D Mark II was mounted on a little aluminium bar (0.7 m) and fixed on the tripod at 2 m from the inscription. Only a single camera, hold on the bar in 3 different positions, has been used. The baseline between 2 adjacent position was set at 200 mm, about 1/10 of the distance from the engravings. In this second application only a limited number of acquisitions were made, even if each one consisted of three camera shots.

The co-planarity among the frames for each hat trick must be maintained to achieve a good correspondences of the points. Settings of the camera represented an important key factor for avoiding noisy point clouds. In order to achieve good dense point clouds it was important to use fixed optic without aspherical lenses. As we know each optic is suffering from radial distortion, specified by the manufacturer. Radial distortions are normally directly proportional to the distance from the centre of the image (principal point). Some optics mount asperichal lenses to correct part of this distortion, altering the camera calibration step (internal orientation).

In order to have a defined image and a good field depth the camera settings were modified by using automatic shutter, diaphragms at f11/f14, ISO sensibility at 100 and infinity

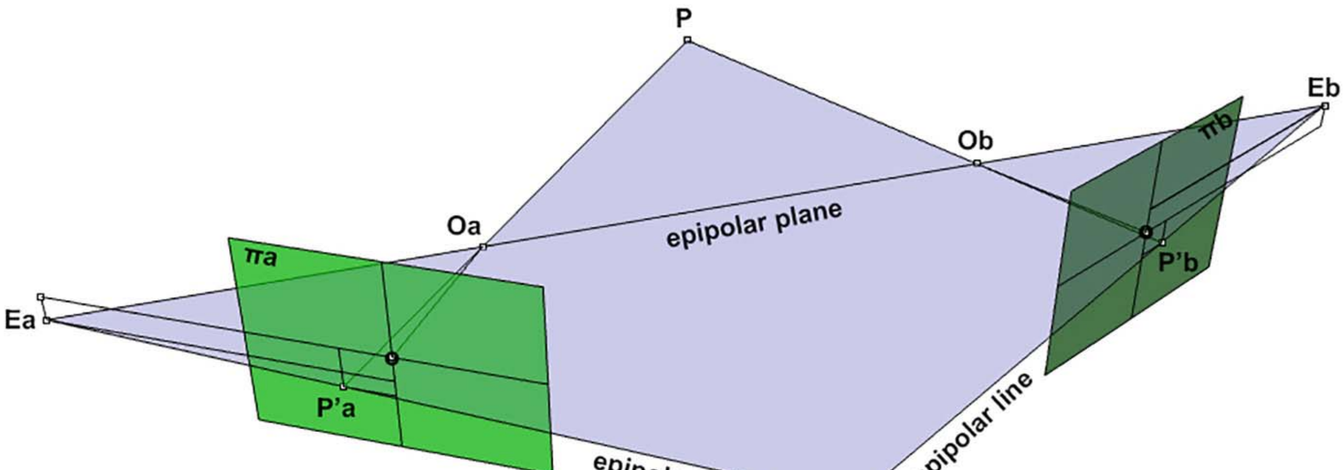


Figure 3. Epipolar geometry. This particular geometry applied to digital photogrammetry allows to recognize homologous points between a couple of frames.

focusing. For the letter of Harkhuf five acquisitions were made to have the complete engravings with different settings and lighting.

The position of the tomb conditioned the acquisition steps. They were carried out in 2 different moments of the day: during the early morning, with direct light of the sun on the surface and during the afternoon with diffused illumination.

Knowing the exact distance among the three camera positions on the bar, it is possible to achieve spatial coordinates of inaccessible points. The system is often used in topography and is known as "space forward intersection". Based on the same principle of the eyesight, space forward intersection allows to reach inaccessible points starting from 2 central projections oriented on the same subject. The geometrical model explains how it is possible to achieve the coordinates (Figure 5).

The accuracy of the numerical model depends on the angle of the collimation straight lines and on the distance of the cameras from the object. It is however possible to demonstrate that the collimation straight lines are twisted lines, so that interpolation is necessary to find exactly the point. Recent studies on this geometrical model evidenced other possible solutions to solve the problem. One of this is represented by the calculation of the middle point between the twisted lines. This is a good solution when the vertical angle of the lines is small. Another solution is represented by an innovative geometrical model named "mutual tipping", developed by Carpiceci in 2012 [10]. This geometrical model allows to control 2 important factors:

- the real phase displacement of the twisted lines;
- the convergence angle of the triangulation.

Currently there is no software that uses this solution to generate dense point clouds, indeed the solution adopted is demonstrated only in the projective geometry. It should be interesting to write a specific algorithm able to use this solution and compare the results with the others.

The SfM system was used to create a high resolution 3D numerical model (point clouds) even if one of the main problems consisted in a non-scaled result (Figure 6). The second system (stereoscopic) generated an accurate and scaled 3D point cloud. In this case the limit consisted in the orientation of the reference system (local) that is in the origin of the perspective pyramid of the camera (the second shot of the hat-trick). In order to solve this problem and process the final

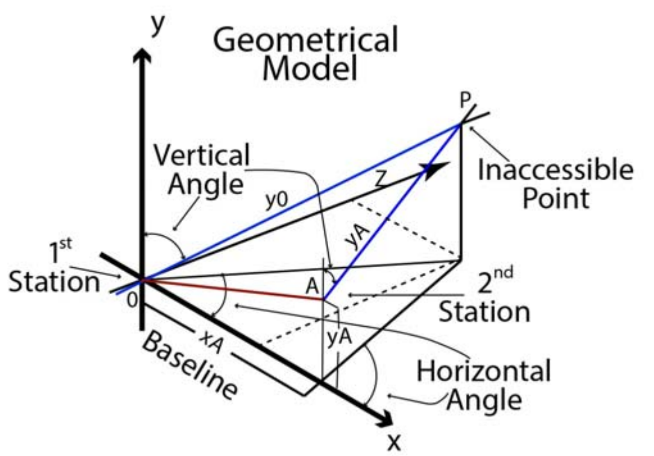


Figure 5. Geometrical model used in topography and implemented for digital photogrammetry.

Figure 6. Numerical model (point clouds) of the letter of Harkhuf preserved on the main façade. The flags show the Ground Control Points (GCP_S) necessary to scale the model. The letter contain 60 million of points.

graphic restitution it is necessary to transform and rotate the UCS in a desired position such as an orthographic view.

Aim of the project was to use both the models. The model carried out with the stereoscopic method allowed to extract point coordinates in order to reference the non-scaled model from SfM. The error registered between the two numerical models and the coordinates is about 0.008 m (Figure 7). The value of the error is not constant over the entire model and the result is referred to the Ground Control Points used to process the non-scaled model. Some factors can change this value such as the exact recognition of the points between the two models, the number of the points used, the different definition of the images taken at different distances from the subject and the resolution step of the two point clouds. The points used for referencing the model (10 points) have been chosen homogeneously over the entire surface, focusing the attention in the corner of the engraved stone.

The accuracy of the stereoscopic model and the job condition influenced the final results of the project. The stereoscopic model is composed of 2.5 million of points and

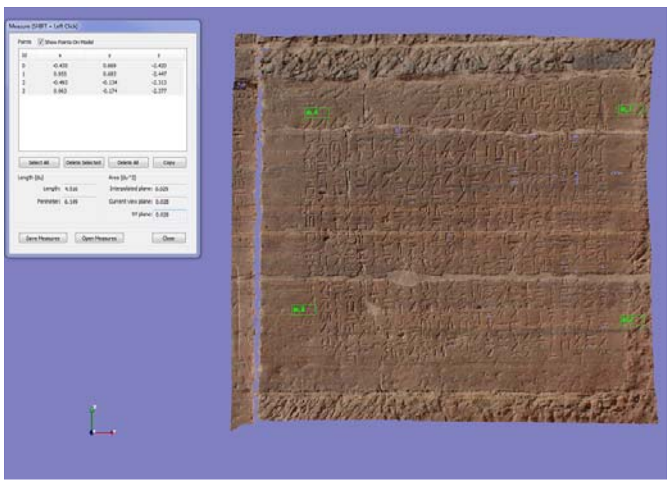


Figure 7. Numerical model from stereoscopic acquisition. On the point clouds coordinates have been picked in order to reference the SfM model.

the resolution is about one point every 1 mm (GSD). The accuracy of the data can only be estimated on the basis of a table compiled by Mencisoftware.

The table evidences the theoretical error of measurements in different condition. With the baseline set to 400 mm and a distance from the subject of 2000 mm the accuracy could be 0.89 mm (Table 1). If we had changed the distance of 3 m from the inscription (3000 mm on the table) the accuracy in theory would be 1.84 mm. Measurements taken on the inscription (length, height and diagonal) corresponded to those taken on the virtual models. Certainly it is not possible to verify the dimension of each hieroglyphic sign, but only testify the entire documentation of inscriptions preserved on the tomb.

Figure 8. On the numerical model it is possible to separate the chromatic characteristics from the shape of the engravings.

3. THE PROCESSING STEP

3.1. The point clouds numerical model

As mentioned above the photogrammetric survey was carried out on the entire archaeological complex but only the letter preserved on the main entrance was completely elaborated.

A specific elaboration procedure was developed for the inscription and the results are shown below. The processing step was performed with different software for point clouds management. The aim of the study was to create a numerical model of the inscription at high resolution, able to give information about its condition.

From the high resolution 3D model (point clouds) it was possible to carry out all the measurements about length, width and depth of the engraving and to get information about the geometry, morphology and the global visualization of the object. With the integration of different point clouds management software it was possible to make a series of elaborations in order to get a better organization and comprehension of the data (Figure 8).

3.2. The transformation of the numerical model

The main elaboration was represented from the transformation of the point clouds in the surface. Despite it seems very simple and fast, this step is very difficult to process, above all when we handle with complex shapes, such as an Egyptian inscription.

Once the filters were applied on the point clouds, the surface reconstruction was executed through the meshing technique. The meshing process was necessary to:

- reduce the total of the points;
- create the connection among the points;
- measure the connected and continued surfaces (volume, distance);
- apply a texture map from the bi-dimensional images.

The mesh consists of vertices that give positional information and edges that give connective information. By connecting the edges to the vertices it is possible to introduce a concept of "closeness" between vertices and give the topological information. The faces are determined when given the vertices and edges. The faces do not introduce anything at the level of information; rarely they can have some associated attributes. Currently a lot of mesh generators exist but the following are the most common, based on the main studies of Owen in 1998 [11].

There are three main categories of mesh generators for the reconstruction of the surfaces, starting from a domain of unstructured points;

- Octree;
- Delaunay;
- Advancing front;

The most used method for generating triangular meshes is that known as Delaunay Criterion (Figure 9). In the Euclidean plane the principle of the method is very simple and it requires that each of the set of the nodes should not be contained in the circle which circumscribes any tetrahedron present in the mesh. For triangulating four vertices ABCD, two are the possible options of triangulation. In order to satisfy the criterion, the solution in which the circles circumscribed the two triangles contain a vertex inside them, must be discarded [12]. This is

Table 1. Table of accuracy of the stereoscopic system expressed in mm taken from Mencisfotware/Z-Scan.

BASELINE/DISTANCE	100 mm	200mm	300 mm	500 mm	750 mm	1000 mm	2000 mm	3000 mm
20 mm	0.04	0.16	0.37					
50 mm			0.15	0.41	0.92	1.64		
100 mm				0.20	0.46	0.82	3.27	
150 mm					0.31	0.55	2.18	4.91
200 mm						0.41	1.64	3.68
300 mm							1.09	2.46
400 mm							**0.82**	**1.84**
500 mm								1.47
600 mm								1.23
700 mm								
800 mm								

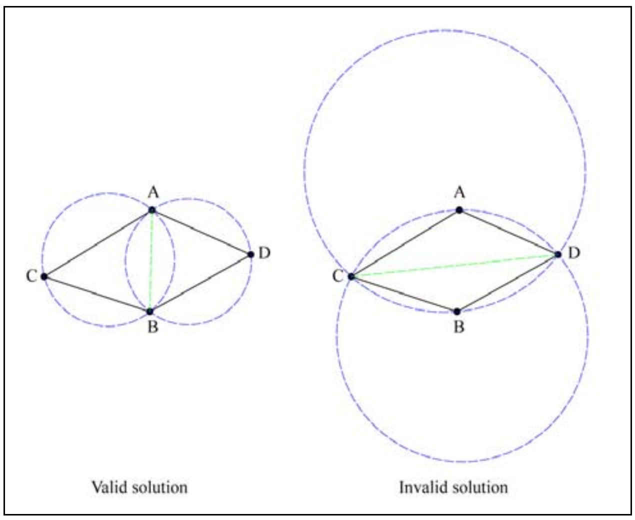


Figure 9. Delaunay criterion showed in the plane. The valid solution allows to have more regular triangles.

therefore not just a real algorithm, but a selection criterion associated to an algorithm which subsequently generates the triangular surfaces. The effectiveness of this method is demonstrated by the relationship between the Delaunay criterion and the Voronoi diagram, that illustrated most of tessellation issues present in nature. The Delaunay criterion is the dual of the Voronoi diagram. It is a suitable system for reconstructing surfaces from unstructured information.

Unstructured point clouds have been processed with Geomagic (wrap algorithm), based always on Delaunay triangulation. The SfM point cloud contained 60 million points. The weight of the point cloud made it impossible to triangulate all the points. It was necessary to filter point clouds reducing in percentage the points by using different filters such as the curvature filter. This filter allows to maintain more points in the area where the curvatures are high.

After the creation of the triangles the surface was improved through the optimization method. Two are the main categories of the optimization method:

- smoothing algorithms, that maintain the connectivity but re-arrange the nodes;
- cleanup algorithms, that maintain the position of the nodes but change their connectivity.

Usually smoothing algorithms alter the original information of the surface, although the final result can be very suitable. Cleanup algorithms are very useful for changing the topology of the triangles. Sometimes it was very useful to flip the connectivity in order to give the correct shape to the engravings. The model was filtered in different ways to highlight the inscriptions but maintaining possibly original data (Figure 10).

Other procedures were used to improve the final model. The following are only the most used for the letter of Harkhuf:

- the repair of the mesh that is required when the algorithmic operation is not completely successful, so the model can have holes, or topological problems (self intersections or corners and non-manifold vertices);
- the decimation filter that uses a series of algorithms to simplify the model and generate multi-resolution models (to pyramid levels);
- the densification or refinement processes to increase the detail of the mesh. Countless are the algorithms for the densification processes (such as Edge bisection, Point Insertion, Templates) [13].

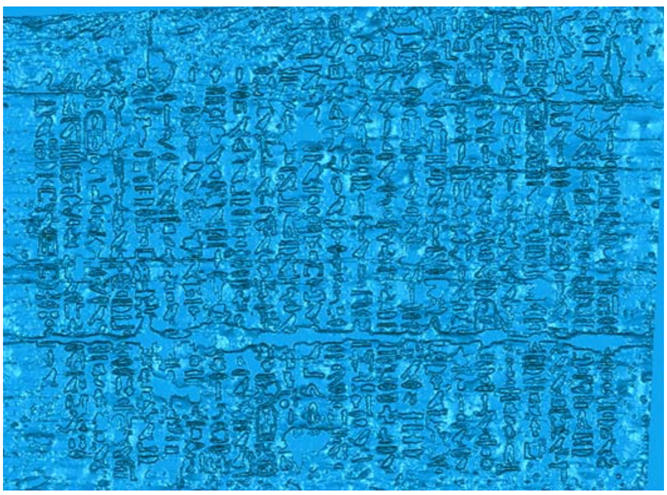


Figure 10. Point cloud was transformed in surface through the meshing technique. The final model contained only 3 million of triangles.

3.3. The virtual scan of the numerical model

In order to read the information about the condition of the inscriptions, it has been decided to create maps useful to the investigation and analysis.

Point clouds carried out from digital photogrammetry are unstructured point clouds. It means that the information is not organized according to a regular grid. Normally image-based data presents only information about the spatial coordinates and the RGB value. It was important to add extra information to the numerical model. In the processing step a new procedure was tested in order to transform unstructured point clouds in structured point clouds. How is it possible to change the structure of numerical data? Data were processed with a specific software (*JRC Reconstructor*) in order to change the structure of point clouds. The aim was to give the same characteristics of a laser scanner data to the photogrammetric data. This idea was possible thanks to a tool, named "virtual scan", present in the same software [14]. This tool allows to make a virtual scan of an object in the virtual space. Once an orthographic camera that includes the numerical model (unstructured) is established, it is possible to acquire the whole point cloud at a specific resolution, such as a laser scanner. At the same time it is possible to create a spherical or cylindrical camera in any position, simulating the same movement of a panorama scanner.

Although the resolution of the results depends also on the graphic card mounted, it is possible to create a new structured 3D numerical model of the subject with the same characteristics of a point cloud taken with a laser scanner. For the inscription an orthographic camera was created at a resolution grid of 4.000 × 4.000 (pixel/points). Subsequently a new 3D structured numerical model composed by 16 million points was carried out. The new structured model contained fewer points than the original one but the main advantage consisted in the possibility to apply the pre-processing algorithms to photogrammetric data.

It was possible to remove the noise and add some useful information such as the normal, the depth and orientation discontinuities. This information has been used to generate different outputs such as Digital Elevation Model (DEM), normal maps and other elaborations useful for the final results (Figure 11).

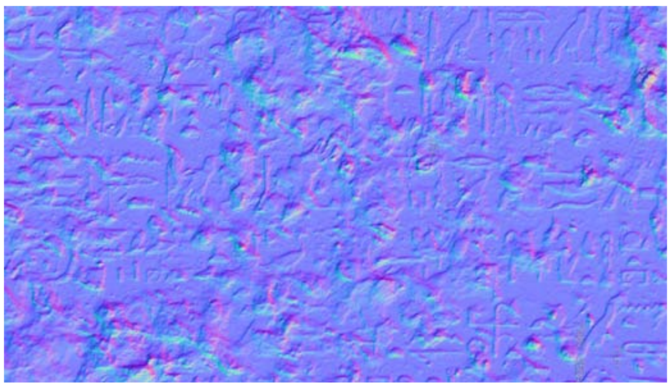


Figure 11. Example of a normal map of a part of an inscription. On the map it is possible to evidence the difference between casual signs and engravings.

4. THE REPRESENTATION OF THE DATA

The aim of the work is not only to have a numerical model but also to find a possibility to use the model to draw the hieroglyphics in a bi-dimensional restitution for the epigraphists. The general idea consisted in experimenting different solutions able to solve the dichotomy between innovative acquisitions and graphic representations.

Usually bi-dimensional representations of the inscriptions are based on direct survey, supported by a photographic restitution on a specific plane.

Unfortunately this kind of representation does not characterize correctly signs and shape of the engravings. The signs are drawn through an interpretation from the rectified image (Figure 12).

Aim of the project was to find a form of representation suitable for the epigraphic signs. A system derived from cartography and above all in the sculpture has been experimented. The approach is based on the representation of the contour lines. Contour lines represent free shape of an object beyond contour outlines and edges of the engravings [15]. The equidistance of the contour lines depends on the representation scale of the graphic restitution. Normally it is set to 1/1000 of the representation scale of the object expressed in meter. In theory an equidistance every 1 mm would be enough but in this case a defined restitution of the inscription was necessary.

It was decided to use the numerical model (mesh) to generate the sections. Sections were set each 0.2 mm (5 times lower) in order to evidence the details of every sign of the inscription. The generation of the sections depends on the quality of the numerical model and also from the main plane chosen from the user. It was necessary to establish a reference plane where the information about the sections are projected. The results evidenced the differences between the old drawings and the new approach.

The signs are well defined by the lines and simultaneously the shape and the curvature of the stone material are described (Figure 13).

5. THE INFLUENCE OF THE CLIMATE

The tomb of the Nobles are carved in the rocks on the west bank of the river Nile in Aswan, an area characterized by hot and dry weather conditions [16], which are typical of a desert climate. In this region the total rainfall amount per year is about 1 mm, and heavy precipitation is a very rare event occurring once every 1 or 2 years, often resulting in flash flood. These rare, but heavy rainfall episodes have important, and sometimes catastrophic impacts, due to the high intensity and short duration, on population, buildings, infrastructures, ecosystems [17], including wadis discharge [18], and cultural heritage.

The meteorological factors affecting the tomb of Harkhuf at Qubbet el-Hawa are air temperature, its diurnal excursion, and wind, and, to some extent, relative humidity.

The effects of the environmental factors, including meteorological elements, are evident if the lower part of the façade is compared to the upper part. For centuries, and until the work done by Schiaparelli, the lower part has been covered by sand deposited on the façade, therefore remained well sheltered against meteorological factors, while the upper part was always subject to the environmental stress. This resulted in a better status of conservation of the lower part in comparison with the upper, which is still clearly visible.

Analysis of the meteorological factors in Aswan show that night time relative humidity can be more than 30 % during the winter months, which rise rapidly during heavy rainfall episodes.

The experiment, designed using portable meteorological instruments, allowed to define if the microclimate around the Harkhuf Tomb has the same characteristics of the larger Aswan area, which can be derived by the meteorological station located at the Aswan airport, and to determine the microclimate inside the tomb. In particular, it contributed to:

- determine the temperature gradient along the façade of the tomb in order to understand if it's different parts are under the influence of physical stress of different intensity;
- determine if temperature excursions together with the right level of relative humidity of the air could favour the formation of dew at dawn and if the air can reach high dew point values.

Preliminary analysis of data collected between 8:00 am and 4:00 pm local time (Figure 14) permitted to detect a differential heating of the façade, with the right part reaching temperatures warmer (few degrees C) than the left and for a longer period, being under the direct sunrays until early afternoon.

In the interior, during the day, the temperature excursion is much more moderate, although the excursion curve is very well correlated with the air temperature outside the tomb. In addition, some measurements of wind intensity and direction

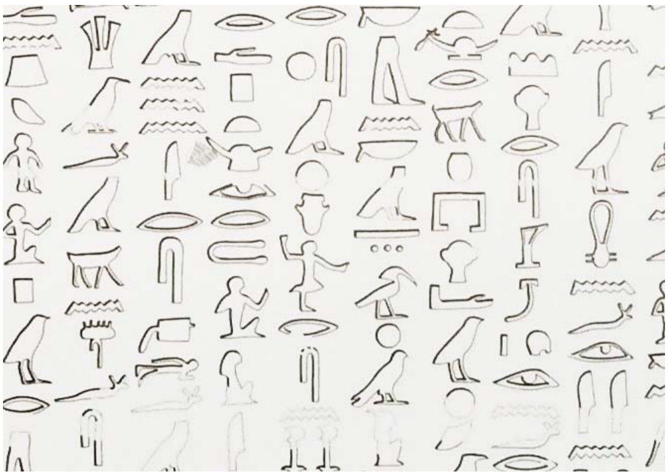
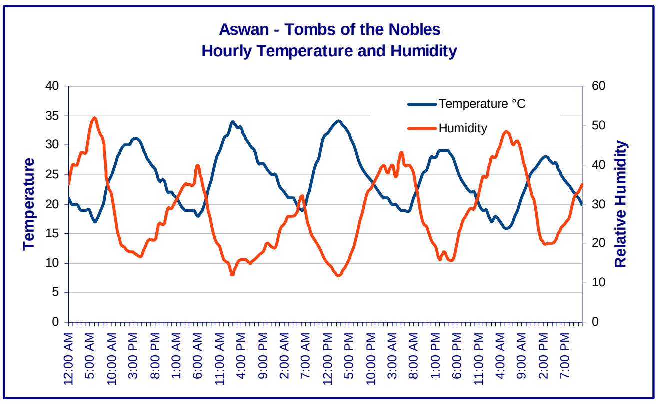


Figure 12. Hieroglyphics drawn with manual recognition of the signs and a conceivable support of a rectified image.

Figure 13. The same part drawn with the contour line method. The equidistance was set to 0.2 mm. This adaptation allowed to represent adequately the inscriptions.



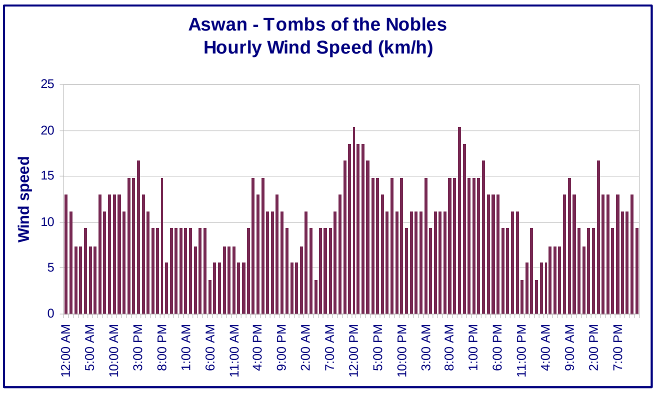


Figure 14. Diurnal variation of temperature and relative humidity (top panel) and of wind speed (bottom panel).

show a persistent wind blowing from N-NE starting mid-morning, around 10:30 am until late afternoon.

Relative humidity of the air outside the tomb does not represent a big concern during the day, however it is important in the interior where it can reach larger values and maintain a risky level during night-time which can favour the formation of mold on the ceiling. During the day evaporation from the surface of the Nile river is considerable and can increase the air humidity in the lower layer of the atmosphere, the boundary layer. This humid air penetrates into the tomb and remains trapped and starts to condensate and deposit on the internal walls and ceiling increasing the risk of mold formation.

All these environmental factors certainly play a key role in the deterioration of the monument and in particular of its façade so magnificently engraved, making its preservation and conservation an absolute necessity. In this respect the methodology described in the previous paragraphs represents a great tool to this purpose.

6. CONCLUSION

The integrated methodology applied to the Tomb of Harkhuf has given good results. The research evidenced some important information about the characteristics of the letter (the support, the signs, the degradation). The experimentation has given the possibility to investigate the documentation of the tomb from different points of view, testing different elaborations that can evidence new information.

Particular attention was paid to the procedure known as "virtual scan" able to transform unordered data from image-based methods in structured information such as range data. This application was very interesting and other experimentation will be made in the future. The team is elaborating the entire data in order to render an accurate documentation and to plan a conservation project.

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