THE CONSTRUCTION OF AN ANCIENT BAS-RELIEF REPLICA USING PHOTOGRAMMETRIC METHODS AND CNC TECHNIQUES

E. STAMBOULOGLOU, Managing Director, Fotopo Ltd, Greece

Commission V, Working Group 4

KEY WORDS : Photogrammetry, Archaeology, Reconstruction, Close_Range, Three-dimensional

ABSTRACT

This paper describes a replica efficient production process of ancient sculpture with bas-relief, avoiding totally the contact with it. Analytical Close-Range methods combined with Computer Numerical Control (CNC) techniques make possible the construction of the replica. A strong point of the process is the possibility of endless replica production in the same scale or smaller scale.

1. Introduction

The construction of replica of ancient objects like sculptures and bas-relief is a routine process for the Archaeological Service, the Archaeological Schools and Museums.

The conventional technique which is used to obtain such replica consists of two steps. During the first step the technician make a negative surface of the original object using a special rubber material. To obtain the desired results the original object must be placed in horizontal position to facilitate the application of the liquid rubber on top of it. Additional rubber material is also needed in difficult areas with hidden and negative concave surfaces.

Soon after the rubber solidification, the technician can produce the desired positive replicas with the same negative rubber but not more than a few copies. The reason is that the rubber is damaged with every use. This is the second step.

The described conventional process is applicable to object which can be moved to horizontal position and have a skin-surface which allows the contact of the rubber material.

The Committee for the Conservation of the Monuments of the Athens ACROPOLIS, signed a contract with our company for a pilot project concerning the investigation of new methods and techniques for the production of replicas avoiding the contact of the damaged original object with any material, with an accuracy of 1 millimeter.

The pilot project was designed and realised in Greece, by Greek scientists and technicians.

The proposed original object was a 1,20m X 1,10m marble bas-relief plate from the Zoforos of Parthenon (0,15m maximum relief), the first from the Procession of Panathenea. The traces of air pollution, erosion and brutal human action transformed the invaluable monumental bas-relief to it's present status.

2. The Photogrammetric Process

Conventional Close Range Photogrammetric method was applied for the detail survey of the original object in order to avoid any contact with it.

The object is situated in vertical position on a special stand inside the Acropolis Museum. Several (13) pre-marked self-adhesive control points were put to cover the object space. The set of 13 control points were determined using special techniques and combined measurements with digital theodolite and metal tape, with sub-millimeter accuracy. The maximum depth of the object relief is of 15cm having some difficult small areas with negative (concave) surfaces. In order to cover those areas, two pairs of photos were taken with an UMK /10-1318 camera from a distance of approximately 2 meters.

The Analytical Stereoplotter Digicart 40 was used for the restitution of the two stereoscopic pairs. An enormous number of 3D-break lines and 3D-points formed the restitution data for the detailed representation of the object and contributed to the formation of the object surface. The rms residuals (X,Y,Z) of absolute orientation for both couples were within 0,3 mm.

The restitution file was transformed in DXF format in order to be used in Autocad R12. The graphical representation of the surface was made with 1mm contour lines, produced with QuickSurf/ SCHREIBER, a vertical application of Autocad R12.

A detailed map with the 1 mm contour lines, in scale 1 : 1 was plotted. With the use of QuickSurf a digital surface (binary file) was produced together with an output file in 3d-mesh form.

3. The CNC process

The CNC machine works with data produced and organised by special S/W. The existing S/W are designed to cover the needs for the production and construction of objects with few surfaces described with simple 3d-planes and 3d-curves.

Three different S/W were used for the process and the production of the required output for the CNC machine. All of them failed to process the surface data, not even a portion of it.

Finally after many attempts and tests the process was realised successfully by one of the three S/W, the Personal Designer, running on a UNIX, RISC based computer, using small areas of the total surface equal to 1/270 of it. It is possible that the other two S/W can process the same small area, although we did not test it.

The surface was first divided in 9 blocks derived from a 3 X 3 division. This selection was imposed by the CNC machine cutting stage range which can handle objects with 50cm X 70 cm dimensions.

Many attempts guided us to the final selection of the operational dimensions of the surface slice to be processed. Each block was subdivided in 30 slices forming two columns of 15 slices each (figure 1). Every slice was processed separately and finally every block was formed giving an output file for a 3d-axis CNC machine. Drawing 2 is an axonometrique vue of a portion of the surface, representing the head of a horse in the midle and a man walking behind.

The nine blocks were reproduced (cut) on identical MDF rectangular cubes with dimension 50cm X 50 cm X 17 cm. Every block needed a working time of 8 hours on the CNC machine. Two cutting instruments, 1.2mm and 4mm of diameter, were used for the reproduction. The first with a step 5mm to prepare and facilitate the second cut and the second for the final cut with a 0.5mm step.

Finally the nine blocks were put together in horizontal position with perfect and accurate surface-edge contact. A negative rubber surface was produced from the MDF surface. A gypsum positive replica was produced from the negative rubber surface.

The gypsum replica and the graphical representation (map) are included in the permanent exhibition of the Committee for the Conservation of the Monuments of the Athens ACROPOLIS.

4. Conclusions

The produced object called a "mechanical replica", can give an alternative solution for many purposes where an "artistic replica" (hand made) is not needed.

A strong point of the process is the possibility of endless replica production on the desired material, in the same scale or smaller scale.

The requested accuracy within 1 millimeter, can be easily achieved with special but conventional methods and measurements.

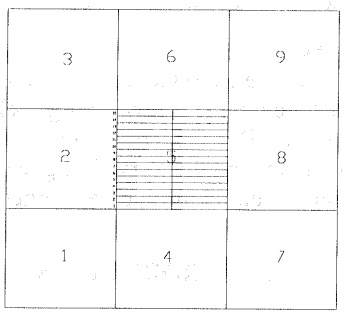
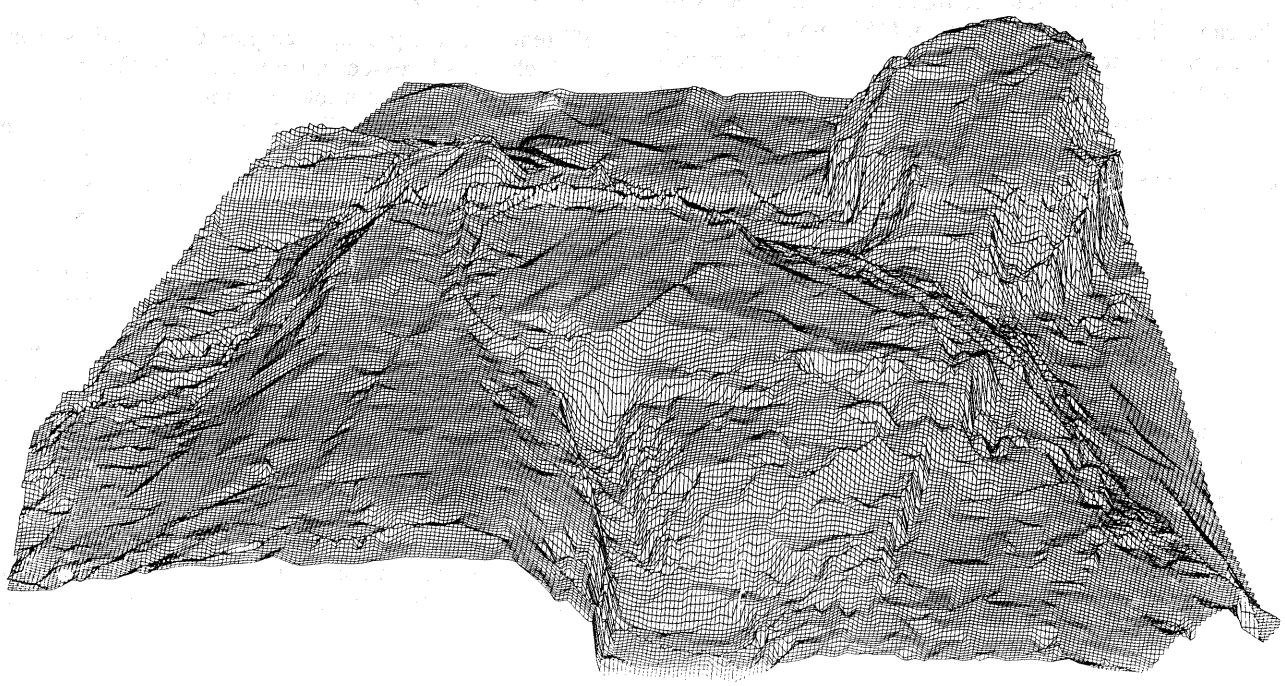


Figure 1



Drawing 2