# DIGITAL PHOTOGRAMMETRY FOR ARCHAEOLOGY: THE PRE-HISTORICAL GRAFFITI IN CAPO DI PONTE (BS)

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## ABSTRACT

The original committment for this job came from the Regional Archaeologic Supervising Authority and its final aim is to build a kind of LIS, for organizing and managing the spatial and semantic informations concerning the Ancient Graffiti Park area, in order to help the archaeologists in their studies.
In this paper we will describe the photogrammetric survey, the different methods we applied for the plotting of data and all the "tips and trics" that revealed to be necessary for rectifying such a strange kind of images.

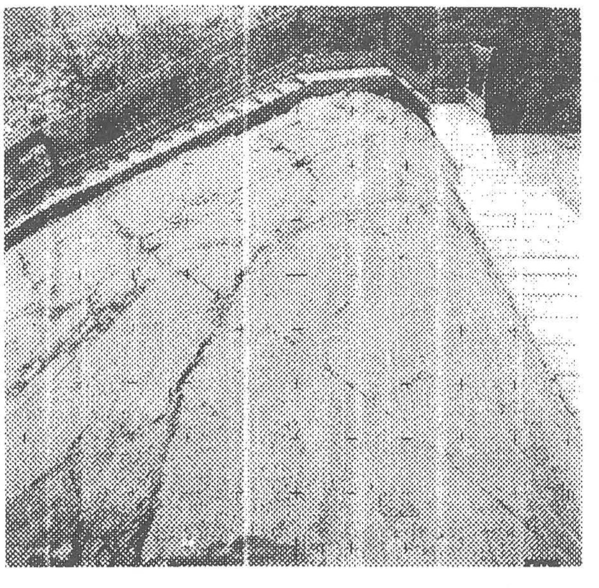
## 1. INTRODUCTION

In March 1996 the Archaelogical Autority decided to improve the quality of the documentation concerning the ancient engravings in Capo di Ponte, by creating a Land Information System. Such a system should obviously fit both the adminitration pourpouses and the archeaologist's need for a support.
In order to respect this general indication we decided to build a kind a LIS where all the data concerning the Graffiti Park, from managing to studies, could be stored, used and updated without overlapping or hiding each other.
The first element which came to evidence after the decision was taken has been the need for high descriptivity level imagery of the rocks, which are undoubltly the focus point: so the photogrammetric way seemed to be the most indicated, and a research group was created for investigating on what kind of photogrammetric survey and restitution would have been the more suitable for this peculiar application. The team was leaded by Proff. G.Bezoari and A. Selvini, from D.I.I.A.R. Politecnico di Milano and from Prof. M. Stephani from Lehrstühl für Photogrammetrie und Fernerkundung, Technishe Universität München. The team was split in two and the Italian part was charged of testing traditional photogrammetry, low cost digital photogrammetry and experimental mixed techniques while the Germans were completely into full digital photogrammetry applications.

## 2. PHOTOGRAMS ACQUISITION

For this part of the work we choosed the largest and most difficoult site among the others in the park, according to the idea that in this way "it couldn't be worst" and so the results we could obtain would have been made more reliable and meaningful.

**Figure 2** - One of the original Rollei 6006 photograms



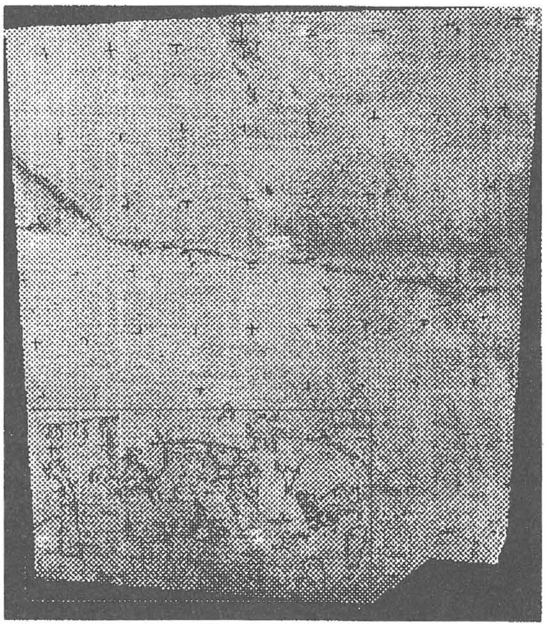
Our photograms were taken by a Rollei 6006 semimetric camera, because the use of a metric device was made impossible by the heavily irregular ground, as the horizontal free land around the test rock was hardly enough for the light and small Rollei tripod.
Furthermore the camera would have worked at no more than 3 or 4 meters from the target and this seemed to be quite a good assurance for the rollei to be enough.
The first problem we met concerned the natural lighting condition: those were unlikely to be good unless we took the picture at either rising or setting sun time, because the subject, the graffiti, could come out with few evidence when hit by direct light. We came to a partial solution for this problem by paying particular attention to the exposures and to

the shutter timing. Anyway, once the problem has been pointed out, many solutions can be applied: wetting the graffiti area to improve the contrast or using tangential artificial spotlights are just two simple tips to get free of the impeachments given by the thin relief of the graffiti.

### 3. TOPOGRAPHY AND PHOTOGRAMMETRY

The measures of the topographic reference network was realized with an alloy tape on a theoric grid, composed of 48 tie points, approximately 1 m spaced and directly signalized on the rock's surface with 5x5 cm black&white butterfly markers; for the elevation coordinate a Zeiss level was used.
In the end, a set of 68 6x6 cm slides were taken and a good half of them seemed to be quite satisfying in matter of contrast and brightness.
The selectioning phase was obviously conditioned by the need to cover the whole rock's surface by using only the well contrasted slides set and for this reason we were forced to use for the final restitution a group of pictures which weren't homogeneous under the aspect of the taking direction.
The selected slides were used for analitic stereoplotting of outstanding points and network nodes on a Galileo Digicart 40 Stereoplotter. The result was an oriented seeding shield of 6547 points describing the stone surface. Those points were converted from tipical Galileo to DXF format and visualized by Autocad graphic editor interface. Once accepted as good the file has been translated again in ASCII standard to be loaded into the DVP triangularization module.
DVP (stans for Digital Video Plotter) was to be used to manipulate the original pictures: so the slides were magnificated and printed and the original 6x6 size became a 12x12 paper. Those printouts were all scanned by an HP4c device. The scanning density was set to 254 dpi: at a first lookout we know this could even seem an insufficient choice and make one ask how comes such a humble resolution to be used for professional digital photogrammetry pourposes. The original pictures we used for scanning were at an average metric scale of 1:30 (while the original slides were obviously at 1:60) and a 100m pixel meant a 3 mm space on the ground: being our commitment specifications of a 0.5 cm.
The interior orientation and the space resection for one image were performed and the final results for those two procedures gave, in the worst case, a residual of approx. a half cm.
This result of this test showed us how the low resolution can be used for this kind of work without losing interesting data and giving a great improvement for elaboration speed : our 6.7 megs image could be interely resected in less than half an hour.
So, the internal resection was made first on all the 121 repairs of the complete réséau an then on 9 points only. The quality of the least squares compensation residuals has shown to be quite incorrelated with the number of used points; furthermore it seemed to be a little better when using 9 points only; so we decided to resect the photograms on the 9 crosses set. Just for instance, the residuals we obtained were around 10 m.
The external resection created some more problems because of the humble visibility of certain control points that forced us to some ugly collimations.
Anyway the general quality of the external resection was satisfying and the worst residuals on the affine transformation that relocated the points in the object space were around 4mm with a mean value of 2.74 mm on the ground.
The resected images has been projected on the DEM, according to the rototraslated plane direction and 14 single ortophotos were created.
The following step was to mosaic the 14 pieces into a single complete and geocoded otophotomap. This was obtained by using the Mosaic external module of the Leica system which allows the ortophotos to be introduced in random order and automatically computes the overlaying patterns into average radiometric coordinates. The result was geometrically very reliable but the radiometry needed to be adjusted and balanced.
The radiometric corrections were made by Photoshop, (area fitering) Photostyler (pixel cloning) and Corel Photo Paint (resampling).

**Figure 1**: The suface of the rock after the rectification with a vector area enhanced



### 4. PLOTTING OF THE ENGRAVINGS

The last step of this test job has been to extract a vector layer from the ortophotomap. The z informations, contained into the DEM, were obviously a little less reliable than the planimetric data set but, even if coming from an interpolating surface our

vector plotting has shown to be quite exact and to fit perfectly the commitment specifications.
In a second phase we met with the german group for beginning to compare the result of the full digital process with the "production level" that was obtained in Milan.
In TUM we used the HORUS system for automatic edge and line detection on three sets of pictures: the low resolution files which were used for the other test, another Rollei picture set, b/w and 800 dpi and the digital camera NIKON/KODAK DC420 downloads.
In these three cases very different results were obtained, depending on the pure geometric resolution of the imagery: HORUS routines were completely unable to use the low resolution full color set, becouse the main algorithm needed to separe the 24 bit file into three 8 bit band coded subfiles and process them separately.
This caused a loss of data in terms of gradients that forced the system to work with too poor variations: the lines of the engravings were so irremediately lost. The second set of scanning gave lightly better results, because the 256 gray leves images stored all the gradient information which was really available in the data, furthermore the highest resolution images helped HORUS th detect the virtual edges which described the perimetes of the engravings. Anyway the complete absence of the human contribution caused the system to confuse in quite a serious way the lines of the rock with the graffiti, and the vector plan which resulted needed to be heavily corrected in a second editing phase.
The better results with HORUS system were obtained by the native digital pictures were all the informations were directliy stored by the camera: even if all the pictures were resected and rectified on the same DTM and with the same software it seems that the lack of a scanning phase helped the system to find in a more reliable way the gradients of the graffiti texture.
In this moment a second level test phase is in progress, for defining in a statistic way the overall quality in terms of accuracy, precision and fidelity to the real data of the two methods.

## 5. CONCLUSIONS

It's obviously difficoult to give a kind of conclusion when an important part of the research is still in progress, but the indication we obtained from the part of the job which has been already concluded are likely to point out the great gap which still exists between human headed operations and fully automatic routines.
The high amount of semantic information in front of the pure geometric data causes this really peculiar work to be very difficoult to make with HORUS system, which anyway proved to be an efficient and powerfool tool for other kind of applications, in order of the real impossibility to have a control on the "decisions" of the system whic by now cannot operate in an autonomous way, for trying to product real maps.
The next step we will take into this research project will be to find a way to let HORUS "understand" some semantical aspects of the scenes it processes, by using clustering operators which can put geometrical and mainly logical /semantical limits to the automatic detection process.