DIGITAL PHOTOGRAMMETRY FOR ARCHAEOLOGY: AN APPLICATION FOR THE ANCIENT ENGRAVINGS IN CAPO DI PONTE (BS, ITALY)

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ABSTRACT

This application of automatic extraction algorithms for the detection of low contrast linear features, as engravings are, is still work-in-progress. In this paper we present the actual research development state and the guidelines which have been defined until now.

1. INTRODUCTION

The problem of detecting the low-gradient linear objects which constitute the engravings was approached by considering it as an operational step, meaning with this that the result we had to aim to had to be something really usable and useful. This kind of approach derived from the fact that the job itself was a research item which came out from an application oriented charge, where the need was to apply for a good solution to a real practical problem.

While realizing the 1:5 scale maps set we understood that our ability, as surveyors, to plot the real shapes of the engravings wasn't supported by a sufficient knowledge about the graffiti themselves: this caused too many misinterpretations and lacks of detail for making good maps. The first remedy we supposed to use was to set up some "mixed teams", where an archaeologist and a surveyor worked together the first for the photointerpretation items and the second for putting into practical operations the indications given. The quality improvement we could obtain by this "mosaic" of knowledge was definitely outstanding and those results were immediately considered as the "state-of-the-art" for 1:10 and 1:5 scale plotting but we also had to admit at the same time that the time needed for such operations had overwhelmed any scheduling forecast.

When thinking of that as an open question, two main ways showed soon: either

the archaeologists who study the ancient people of the area could be trained in digital photogrammetry techniques to plot autonomously the engravings from the orthophotomap that we had already realized or the surveyors themselves needed to learn much in paleography and other historical-social connected items to carry the whole job to the end, including vector plotting phase.

Both of these solutions resulted to be unpractical, because of the highly expensive need, in terms of time, resources and stress, for training some professionals in completely unknown matters to obtain hybrid single operators who couldn't, anyway, substitute in a satisfying way the mixed teams. So, it resulted clearly that one couldn't be requested to be a good photogrammetry scientist and a good archaeologist at the same time.

The third way we supposed to follow was to try to give the archaeologist some tips and tricks (meaning, something which could work this way to them) to limit their involvement in photogrammetry operations and obtain, at the same time, to set the surveyors free from "technical support" service providing.

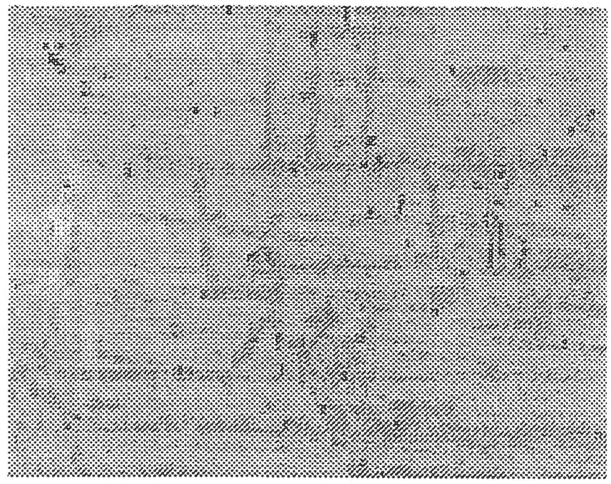

Fig.1 Engraving Raster Orthophotomap

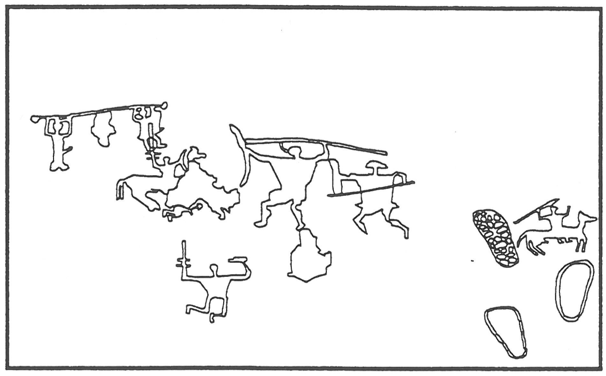

Fig.2 Engravings Vector Plotting

2. PROBLEM IDENTIFICATION

The first way that has been followed to pursue that task started from isolating the problem and individuating its main features. The engravings are definitely character-

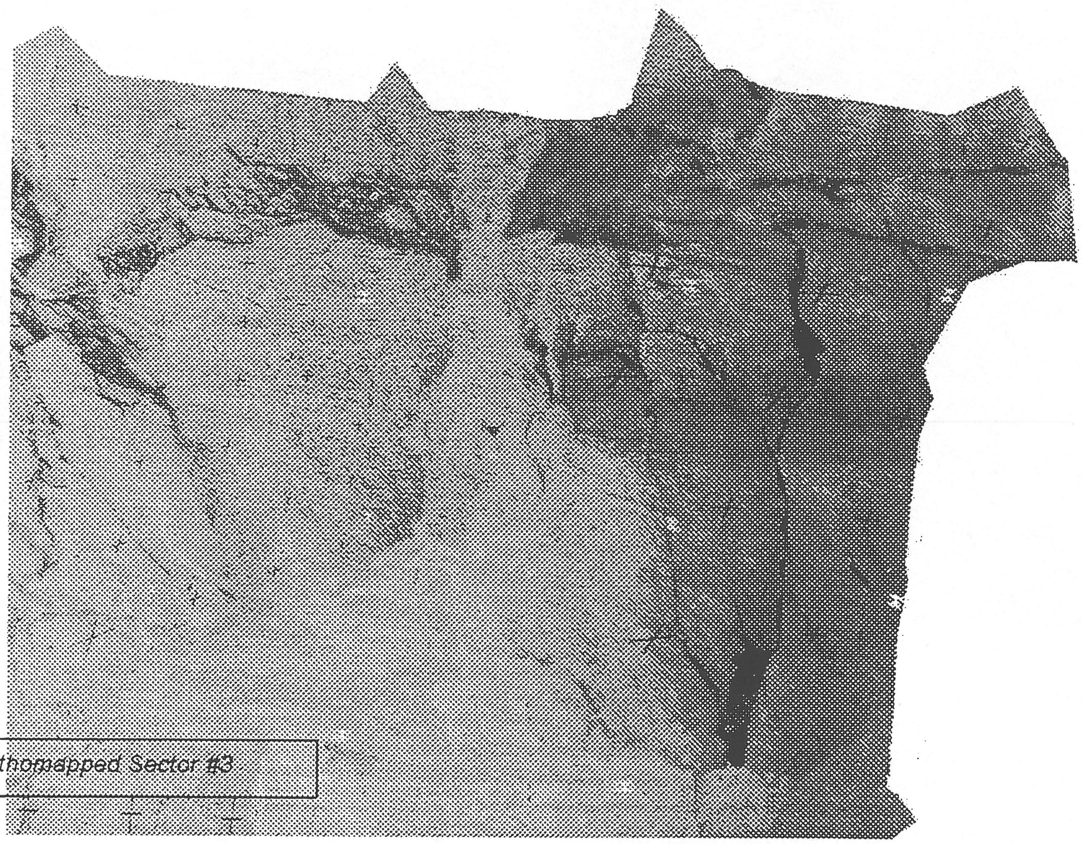

Fig.3 Orthomapped Sector #3

ized by two fundamental aspects: shape and texture; the first is defined by the borders profiles and the second is the graffiti body itself, where the surface of the rock is hammered.
The border profile can be considered without going too far from correctness, a linear feature while the hammered body in the gross, is more difficult to catalogue, as it certainly cannot be said to be a pattern, the engravings being obviously irregularly shaped , and, by the other side cannot be completely considered as a pure texture because of its general unevenness.
The most adaptable definition resulted to be the "class", referring to the radiometric response of the hammered areas, slightly but clearly different from the one of the smooth surface.

3. ENGRAVINGS DETECTION

Therefore the initial problem split in two different ones, the identification and isolation of the linear features defining the contours and the classification of the inner parts. This was needed because none of two peculiarities could be neglected, as the archaeologists needed a vector layer were they could work to individuate the semantic themes of the scenes and a raster map to overlap it. Those were the global conditions for beginning the creation of the program we called *Engravex* (egrav-ings extraction).
Thus, we decided to test the theoretical capability of two standard algorithms for edge detection, such as Sobel and Kirsch operators, as we already had the necessary code kernels.

This check stage was needed to understand whether we could really afford to pursue our task by following that double way, or unfortunately we needed to concentrate on classification only, which seemed to be, at a first look, somewhat easier to perform.
The most outstanding problem we realized soon was the very low gradient values that the graffiti lines showed to have. They were very fused onto the background and that was enhanced further by the two edge detection algorithms feeding needs, as they can use 8-bit files only. This is an unavoidable consequence of the nature of the methods themselves, as one can easily understand, and couldn't be overrun by some simple code re-tuning.
We tested the two operators on 4 kinds of 8-bit grayscale orthophotoprojections (e.g. Bezoari, Papi, Selvini, 1997, Padua ISPRS VI/3 meeting proceedings): full visible bands radiance derived, red band only, green band only, blue band only. The choice of separating the files on the above mentioned three bands was conditioned by the original acquisition format, RGB, which could give us, without any other undesired manipulation on the original data the three specific 8-bit groups.
The first tests results, as shown in the images, haven't been satisfying, and that caused us to doubt of the functionality of the applied algorithms themselves. To solve his doubt some pre-processed test image was created, by using the old manual plotted vector files, overlapping them to the raster ones and merging the lines with the background.

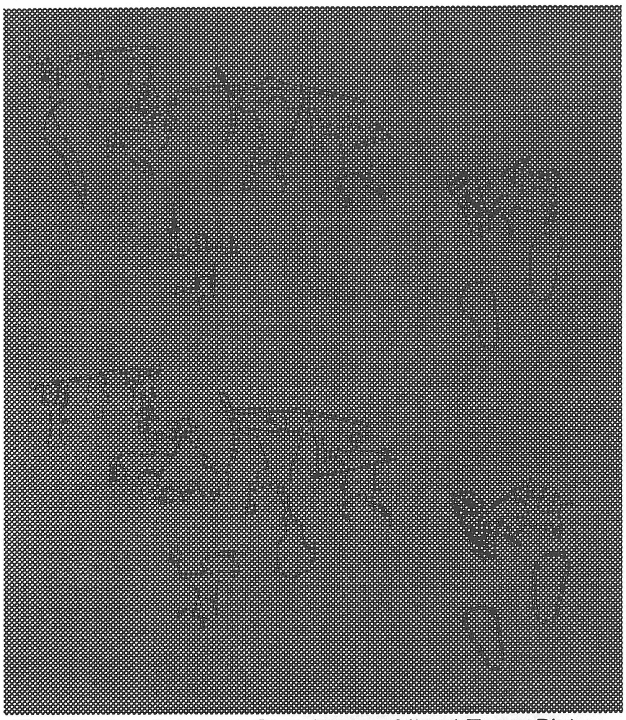

Fig.4 Upper: Surveyor Plot, Lower: Mixed Team Plot

We used different vector color, going from the most contrasting ones to radiometric values which were very close to the raster layer average ones. Then the TPI (Test Processed Images) were split again in the same way we told before, to obtain 8-bit files again.

The new files were then used to feed the Kirsch operator and good results were obtained, as shown in figure. This told us that the real problem we had to face with was just the poor gradient level between the engravings and the background and that the algorithms we used could work properly for the detection of such edges.

So, we arrived to understand that machines and humans suffer in this peculiar application by the same difficulty,

Kirsh Operator

$$G_{kir} = \max(|D_1|, |D_2| \ldots |D_8|)$$

$$D_1 = \begin{matrix} \frac{1}{3} & \frac{1}{3} & \frac{1}{3} \\ -\frac{1}{5} & 0 & -\frac{1}{5} \\ -\frac{1}{5} & -\frac{1}{5} & -\frac{1}{5} \end{matrix} \quad D_2 = \begin{matrix} \frac{1}{3} & \frac{1}{3} & -\frac{1}{5} \\ -\frac{1}{3} & 0 & -\frac{1}{5} \\ -\frac{1}{5} & -\frac{1}{5} & -\frac{1}{5} \end{matrix} \quad D_8 = \begin{matrix} -\frac{1}{5} & \frac{1}{3} & \frac{1}{3} \\ -\frac{1}{5} & 0 & \frac{1}{3} \\ -\frac{1}{5} & -\frac{1}{5} & -\frac{1}{5} \end{matrix}$$

as the low contrast was the endemic bother in manual plotting too. Unfortunately the "grasp" tool cannot be implemented in the code and some other technique must be

thought. The most sweeping remedy consisted in starting over by acquiring again the photograms, after wetting the engravings and using a tangential light to artificially enhance the contrast at the origin. This method will be tested when a second set of photograms will be taken, probably in some months, for other connected purposes.

By now our attention focused on "soft" techniques to obtain the same result.

The most important constraint we couldn't neglect is that we are to obtain a standard procedure which doesn't

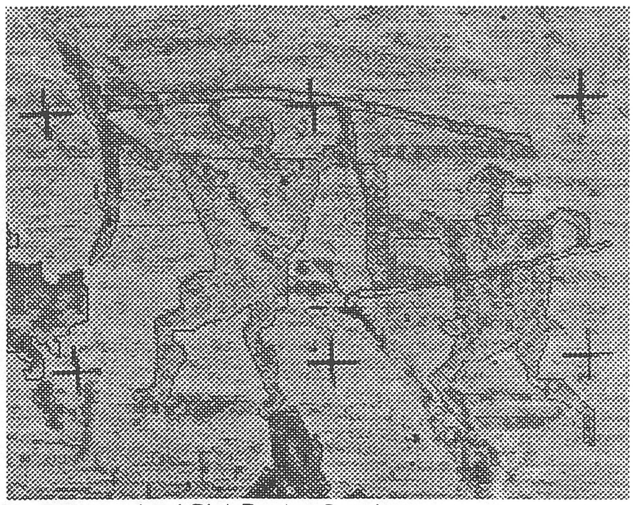

Fig.5 Supervised Plot-Raster Overlap

depend on the single image characteristics and that, on the contrary, could be applied by a single step approach to all the orthophotomaps in the database, in order to give non-trained personnel, such as archaeologists are, a working method to obtain the results they need for totally different purposes.

So we had to find a global operator, in opposition to local and supervised ones, which could be invoked for performing the pre-processing phase. The two stages, preprocessing and edge extraction, should preferably be batched too to easy at the highest level possible the whole operation.

The global operators working on pixel depth we have begun with were equalizing functions, in other words they were curves which transformed the original depth values into "equalized" ones allowing them to be more fitting to the need.

Constant lines resulted to be unuseful because of their little capability to really stretch the gamma while exponential curves gave some results. The further problem which came out while processing the separated images we used for the test was the different absolute position of the values on the 0-255 gray level scale that each picture showed to have. But this was immediately solved, luckily, by the use of radiometrically adjusted orthophotomap shares, which are quite homogeneous.

At the moment we cannot say the pictures can be one-key processed but we can say that we are obtaining encouraging results and that the non-linear global gamma equalization operators seem to fit the problem.

Actually we are also creating some RAW data file where we will try to apply a bi-dimensional clustering algorithm, realized by Dr. Vincenza Tornatore, a member of Prof. Sansò research team, with the interim aim to correctly individuate the most typical gray tones for this imagery sets, to better fit the non-linear equalizing curves on a statistical base, and, mainly, with the future development goal to use it directly by a two ways course for individuating the coarsing of pixel clusters and then their position in the raster map. In our opinion this should bring to an adaptive and radiometry peculiarity insensitive individuation procedure for the hammered areas.

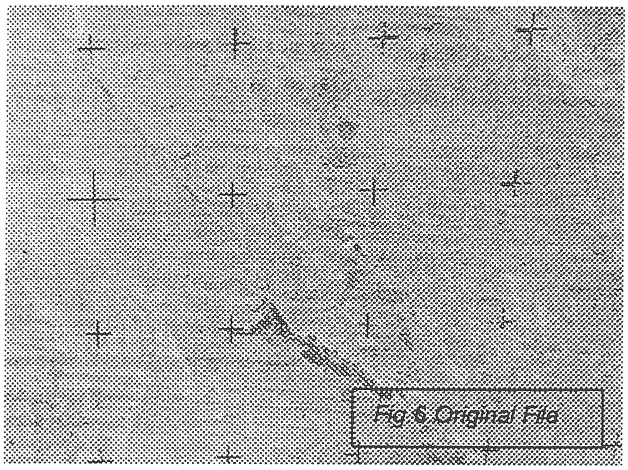

Fig.6 Original File

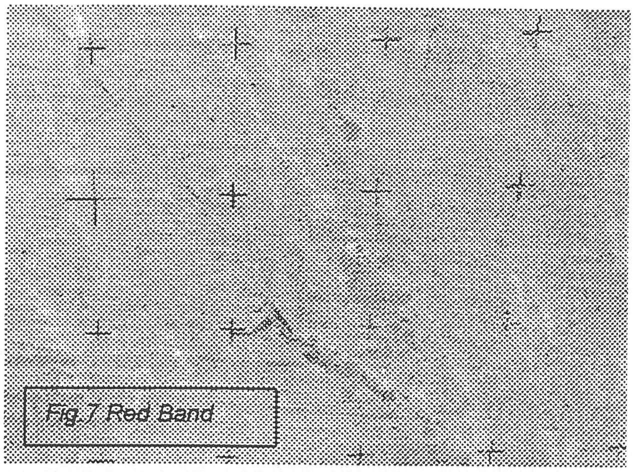

Fig.7 Red Band

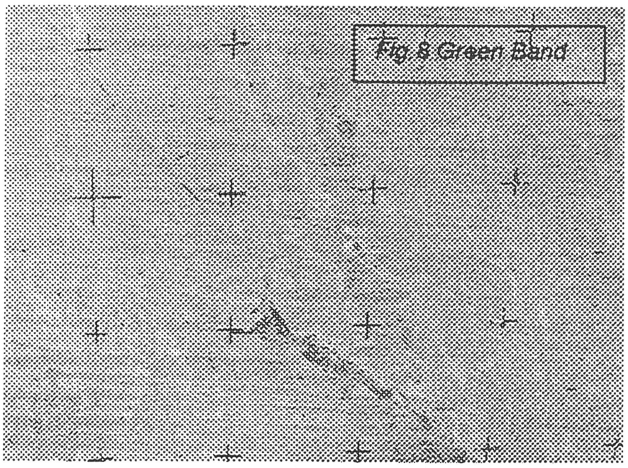

Fig.8 Green Band

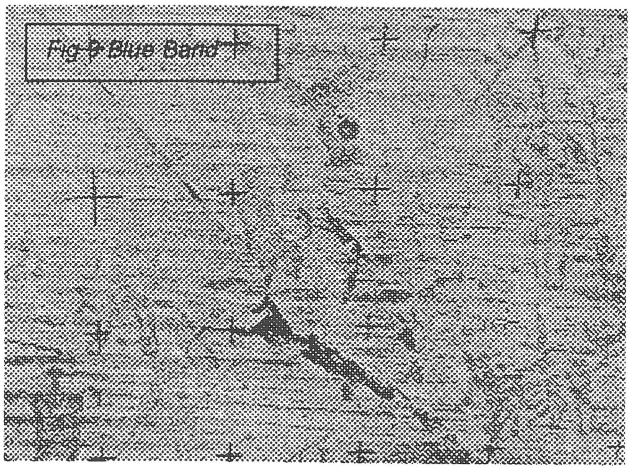

Fig.9 Blue Band

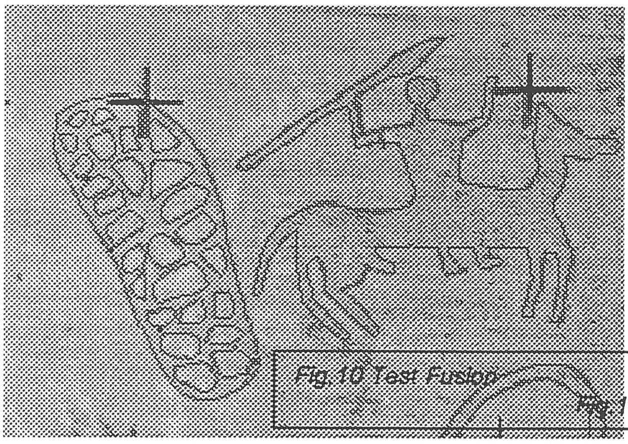

Fig.10 Test Fusion

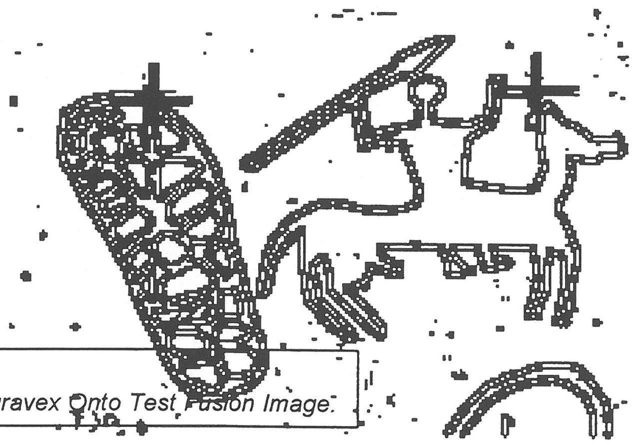

Fig.11 Engravex Onto Test Fusion Image.

4. FINAL REMARKS

One could say that a closed line, such as the one we obtain by edge detection should be, includes a surface and that this surface is the hammered area. This is not true, for two main reasons: first, not all the engravings are closed shapes and second not all the closed shapes are completely filled with hammering.

Finally, when taking again care of the "hammering" problem, we had the idea that the pixel classification methods, derived from remote sensing, could be used to individuate hammered areas on the surface of the rocks and we also realized that a kind of thematic mapping of the engraved parts could also work as a contrast enhancement layer to help the edge detection algorithms in performing their job.

The individuation and separation of fitting pixel classes could also include non-engraved surface erosions, moss and lichen, matter variations and coat gaps.

The tests on the classification algorithms is at the moment we write this paper still work-in-progress too and we will account for this and for all the other suspended items in the following papers.

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