A METHOD FOR THREE-DIMENSIONAL MODELS GENERATION FROM DIGITAL IMAGE CORRELATION.

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Commission no. III
Working group no. III/3

Abstract

The paper gives an overview of the problems in digital image correlation and analyzes the results achieved till now in the field of robotics and of analytical photogrammetry.

Criteria and fundamental concepts for a general approach to the problem are given, as well as the analytical definition and the practical method designed.

Furthermore some simulations and some applications of the suggested method in the field of urban survey are explained with the results achieved.

A comparison is also carried out between these techniques and classic digital stereoplotting in order to asses the reliability of the method.

INTRODUCTION

1. The natural system of stereoscopic perception gives a basis for rational design of three-dimensional models generation from digital image correlation for robotic purpose and to develop the automatic photogrammetric methods.

It is notorious that in the process of natural visual perception, either monocular or binocular, three essential elements appear to be linked together, and precisely: the eyeball, the optic nerve and the visual centers of the brain. The eyeball contains the dioptric apparatus for to detect the objective reality and to record the relative signals. The visual impulses produced by the impact of light on the retina are transmitted after to the brain, through the optic nerve, where the sensation of vision comes to consciousness.

The retina constitutes the beginning element of visual per-

ception. When the eye fixes an object, the image is sharply on a small area of the retina called yellow spot, where the perception of details is enhanced and immediately transmitted to visual centers.

The stereoscopic perception is automatic and comes from a direct natural correlation between the coniugate pixels, owners of the same signals, belonging two different yellow spots. The two images recorded by left eye and right eye are not exactly identical, and that is why of the generation of virual three-dimensional perception.

Several studies have demonstrated the possibility of performing the same task by means of electronic correlation techniques or coherent optical processing. Investigations have carried out also for digital correlation in photogrammetric instruments /1/.

Each correlator system offers advantages for to resolve this problem, but the correlations must be limited to the smallest possible area capable of supporting a specified accuracy level.

For the above purposes various method are presented for the reconstruction of a three-dimensional model from digital stereopair. Current trends in photogrammetry are also toward automated digital processing systems /2/, /3/.

AN ITERATIVE APPROACH TO THREE-DIMENSIONAL MODELS GENERATION

2. The similarity between the direct binocular vision and the indirect stereoscopic generation of space models is notable in many respects. Really, both image processing, in this different systems, are founded on the differences between the coniugate images in overlapping, wich are fundamental for all stereoscopic distance determinations.

Actual procedure in stereoplotting, work out coordinates point by point, after absolute orientation of stereograms. All such intersection points will together form a three-dimensional model, geometrically similar to the photographed object.

The latter is very expensive procedure in digital image correlation and must to be cenverted, with a view to simplify, in area by area, as soon as in visual binocular perception.

After conversion from optical form to digital form of coniugate images, this extension is possibile if the different gray levels are well distributed in the raster representation. Otherwise, the problem to be solved by means histogram equalisation or image enhancement and restoration.

Numerous techniques for computing the correlation function are well known, and some of them are widely used in analog or in digital form. Very important on the subject are, for istance, the direct digital correlation, the Fourier transform correlation and the miscellaneous methods /1/.

An easy procedure for digital correlation of coniugate images may be the best overlapping of coniugate raster representations, gray level by gray level, for to detect the relative differences or local horizontal parallaxes.

The techniques for comparison and correlation of different images of the same object were already presented/4/. If the coniugate pixels are placed along a predetermined line the image correlation becomes one-dimensional /5/.

Very useful in these operations are sometimes the digital edge extraction techniques for to increase the contrast of raster data and to improve the best fitting of coniugate pixels.

From the parallaxes it is possible, following, to determine the digital elevation data and to obtain the three-dimensional model of photographed object through suitable elaborations.

In practice this procedure involves: (1) analysis of histograms and selection of gray levels; (2) best fitting of coniugate selections; (3) measuring parallax; (4) storing and smoothing of the parallax data; (5) formation of the digital model; (6) repeating steps for other selections until correlation is complete; (7) formulation of the final model and output.

The application of this procedure may be not to know the constant of stereometric cameras. Orientation and size of model are obtained, if necessary, through successive iteration from approximate displacements.

The analytical procedure for this generation of models is not expensive, because raster data are conveniently work out.

The sampling and quantization selected are important for accuracy of the determination. Too coarse resolution will miss important details, too fine resolution may be take too much

space. Some improvement can be aschieved however with a new sampling or different amplitude of gray levels.

It is interesting to observe after all that each point of three-dimensional model will spot by four parameters: X,Y,Z coordinates and gray level.

APPLICATIONS AND CONCLUSIONS

3. The suggest criteria are applyed for a test in urban documentation at University of Florence, with kind cooperation of Professor V.Cappellini and another researchers.

For esperimental test is selected a stereogram of the site of Vernazza, taken for cartographic purpose at flying altitude of about 500 meters (Authorization no. 58, 2-2-1981).

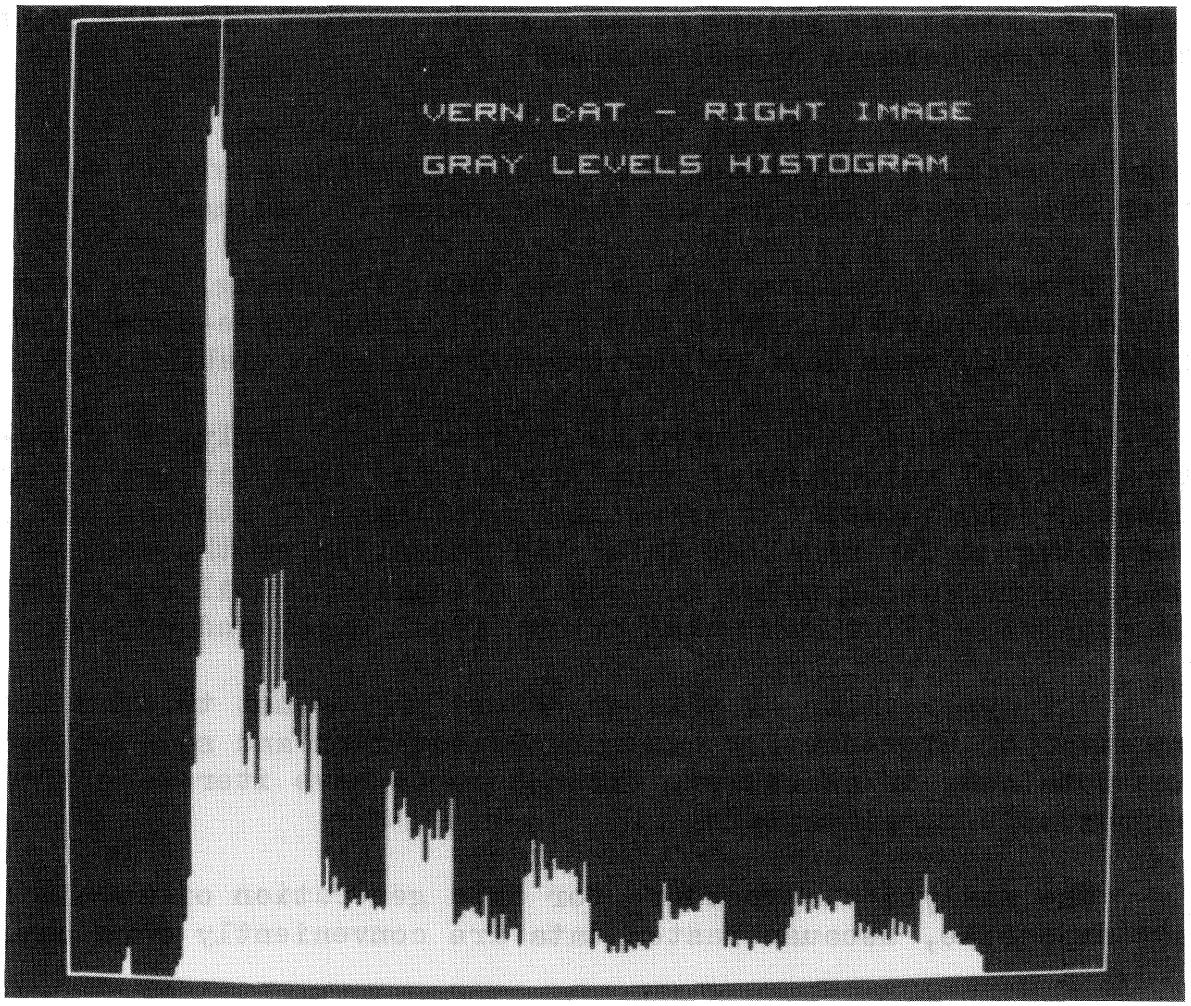

Figure 1

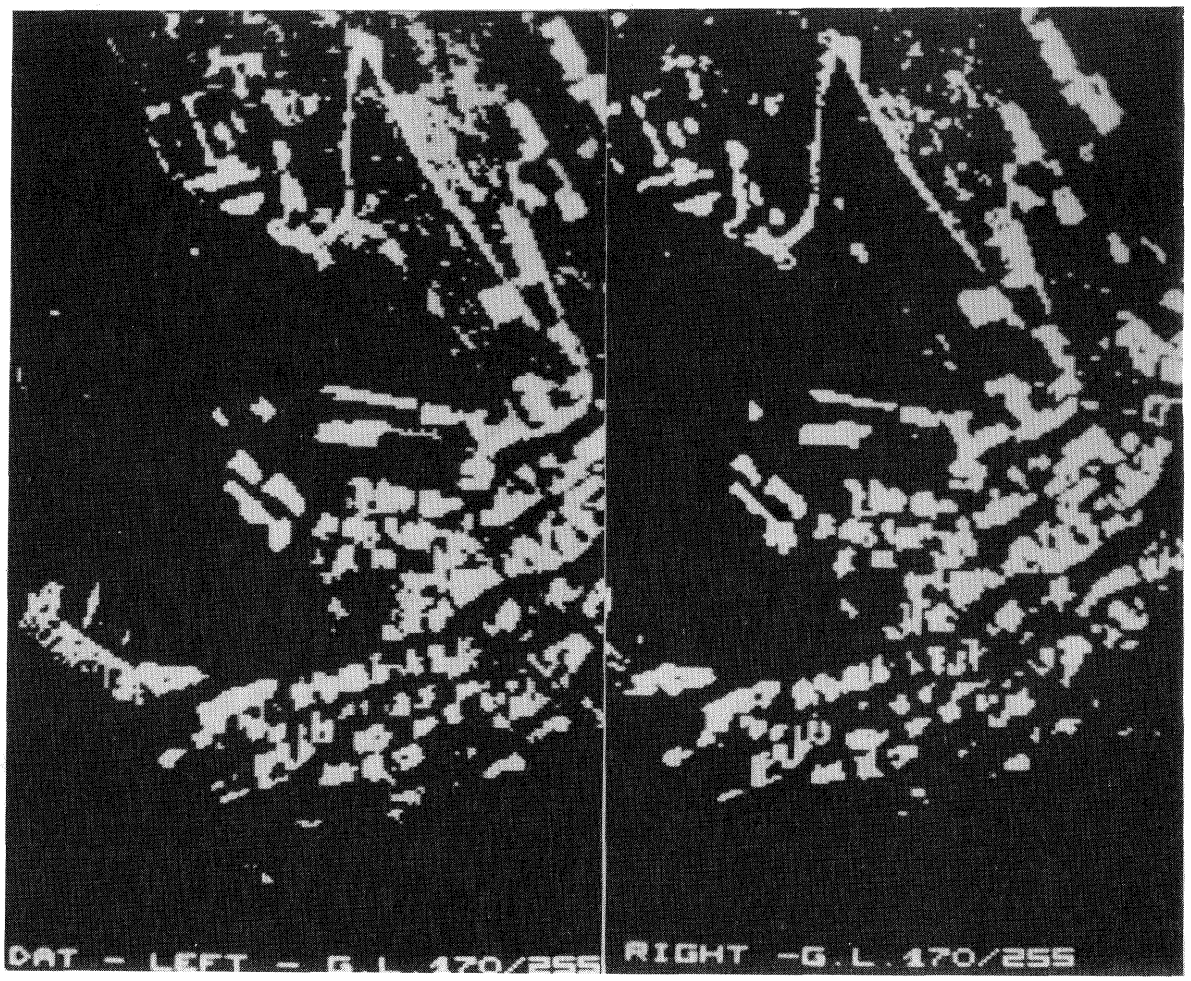

Figure 2

After a preliminary stereoplotting of this stereogram, the coniugate images are converted in digital form and preprocessed for to remove noise and for equalization. Figure 1 shows gray levels histogram of right photogram.

The digital correlation has made on rasterized images at different gray levels and the discrepancies of overlapping are computed by comparison between the coniugate selections /4/. Figure 2 shows the results of selection from 170 to 255 gray levels and Figure 3 shows the results from 100 to 255 gray levels of the same tested stereogram.

The obtained differences, or parallaxes, are controlled step by step with photogrammetric process before the further elaboration of data.

The generation of three-dimensional model has made by interactive operations using double Fourier series for surface fit-

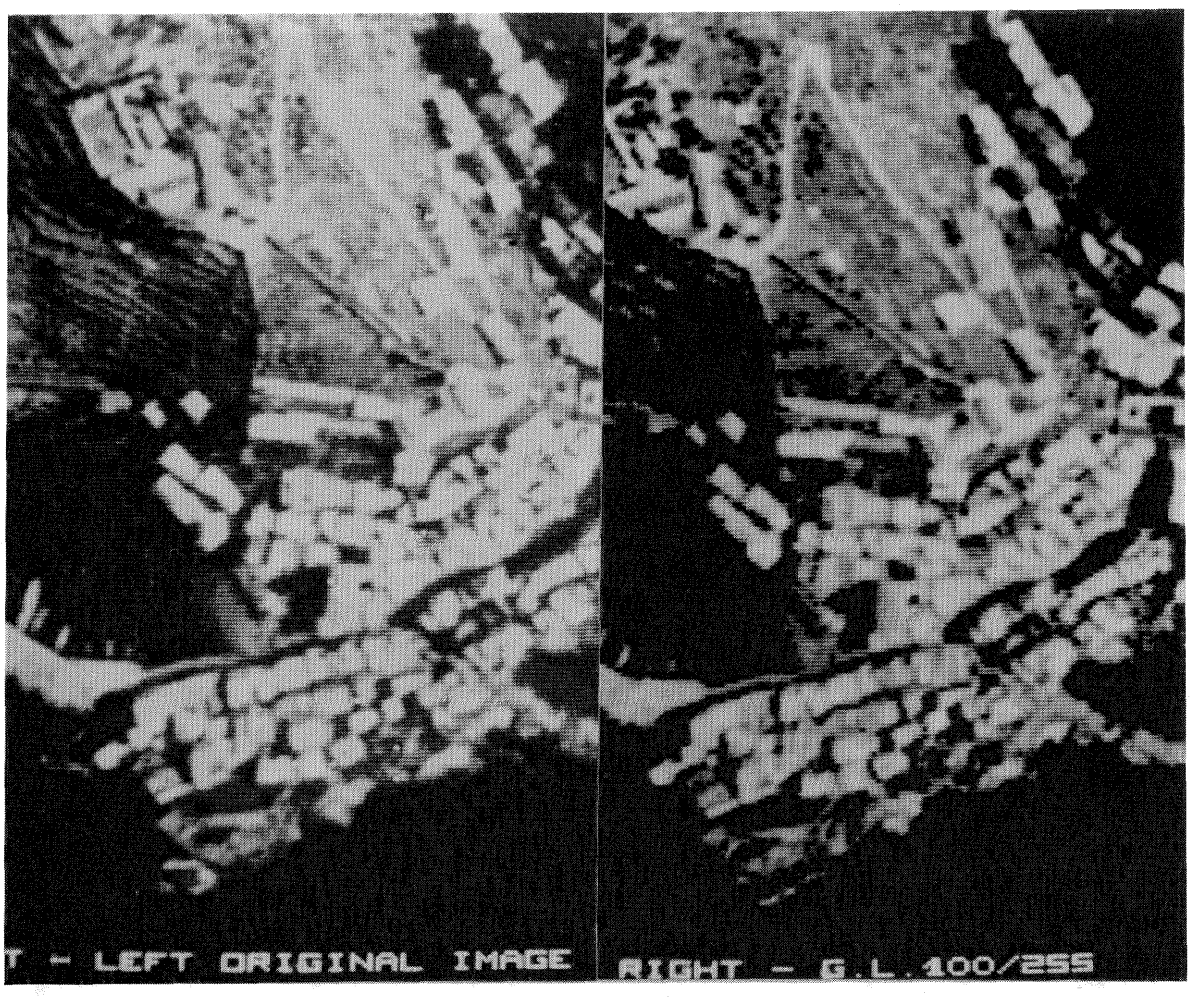

Figure 3

ting of irregularly spaced data /6/.

The morphology of model is checked by comparison with topographic map of Vernazza at scale 1:500 carried aut by Regione Liguria from the same stereogram /7/.

The check has domonstrated the possibility of performing the reliability by means this procedure whenever gray levels accuracy will be acceptable.

New esperiences are under way for to test the same procedure in architectural survey and for to improve the method.

Acknowledgments

The A. thanks Professor V.Cappellini, Doctors C.Conese, L. Ippolito and L.Surace for their useful cooperation and discussions.

This work is partially supported by Ministry of Public Instruction.

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