ST.MARCUS' BASILICA IN VENICE: ANALYSIS OF DIGITAL IMAGES PROJECTION

BRUMANA R., VASSENA G.

Politecnico di Milano
Dip. I.I.A.R. Sezione Rilevamento
Piazza Leonardo da Vinci 32
20133 Milano - Italy

COMMISSION V

ABSTRACT

This research is part of a wider study involving different interlocutors and disciplines for the project of the conservation of St.Marcus' Basilica (Brumana, Galeazzo, Monti, Vio, 1989).
Particularly this contribution is a part of a larger program of computerizaťion that begun with the project of surveies of the Basilica (Galeazzo,1988).
In its latest phase the research has studied the possibility and has evaluated the potential of the image projection technique. Thus the present test is an illustrative tive work focusing on the study of the Basilica's domes.
First it has been tested the chance to proiect the images of the mosaical domes on the digital terrain in a threedimensional space.
The research presents a theorical contribution about the relationship between the survey process and the conservation one, in their most advanced teorical and scientific acquisition (Matteini, Moles,1984).
This study is only at its start and for this reason this paper faces the acpects and the problems of the analytical statement and those ones belonging to the purposes that, it must be said, are not of strictly metric-numerical nature. Infact they are related with the possibilities and needs of control and analysis of the image that, through an informatic support, becomes an operative object. Among the different purposes of this research there is measurableness, the resolution and the possibility of superimposing different acquisition.

This paper is tightly connected with the paper presented at this Congress by R.Brumana and G.Galeazzo with the title "St.Marcus' Basilica in Venice. An apply of image projection on a dome.", because they belonge to the same research.

Key words: Algorithm, Analytical, Architectural, Close-range, Image Processing.

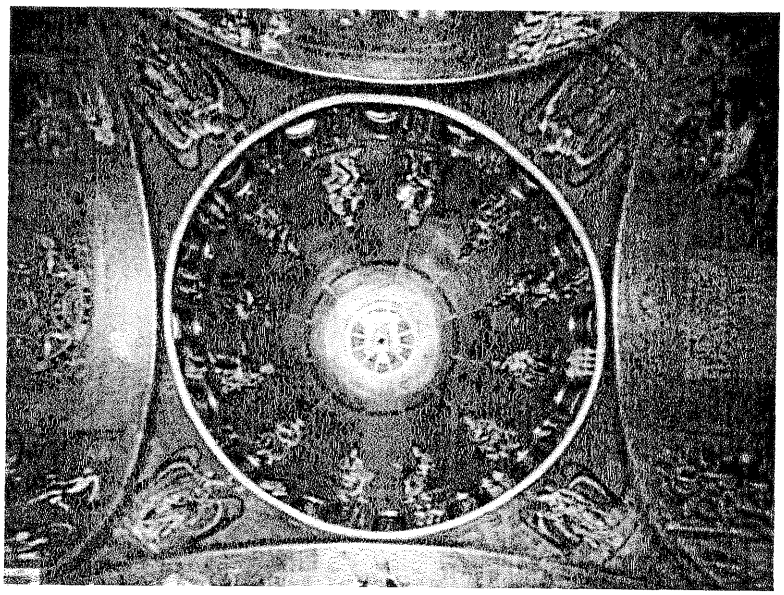

FIG.1 - THE ASCENSIONE'S DOME. DIGITAL IMAGE OF PHOTOGRAMMETRIC TAKENS. HERE IT IS SHOWN AN ACQUISITION WITH SCANNER OF THE DOME OF THE ST. MARCUS' BASILICA.

1 - INTRODUCTION: AIMS AND MAIN CHARACTERISTICS OF THE RESEARCH

The research is open to the actual disciplinar contributions and so it is having a remarkable acquisition and updating in the area of digital treatment.
The methodological process and the main assumptions are here by indicated in their essential parts. Owing to the relative topicality of the research and the new formulation, there is a temporary coming apart between finality and its realization, between the identification of the process through well defined steps and the technical realization through different levels.
The application described here with the realization of photogrammetric takens of a dome of the St.Marcus' Basilica in Venice, the classic restitution with an informatic output, the evaluation of a DTM of the surface of the central dome.
The dome image, digitalized by scanner, has been projected on the DTM described above. Some closer takens, still not utilized, has been realized too, for the need of obtaining a greater resolution that could allow some important evaluations and comparisons in the aim of the research.
The images (fig.1) are obtained through a scanner and a telecamera and later memorized in the archives, for a first cataloguing.
The hardware utilized is reported in the following list.

HARDWARE

IMAGE ACQUISITION:

scanner A3, 400 dpi Howtech,
24 bit (16 millions of colours)
output: TGA, TIF

IMAGE PROCESSING:

PC 486/33 Mhz
with graphic card Vista, 24 bit
(16 millions of colours)
Workstation IBM Risk 6000/320
Workstation HP 9000/835

SOFTWARE

IMAGE PROCESSING:

Pbmplus (on HP 9000/935)
Rayshade (on Risk 6000)
XV (Risk 6000)
Photostyler (PC)
Autodesk 3D Studio
Personal modifications
on Software conversion

Images given in the TGA and TIF formats permit to obtain an high resolution connected with the technical characteristics reported in the last part of this research.

2 - DIGITAL IMAGES AND THREE-DIMENSIONAL SURFACES

In the evaluation of the state of conservation made in this project the extraordinary mosaical richness patrimony of both the plane (floor) and curves surfaces (domes) could not be negleted. The graphic restitution of the mosaical floor, has shown all its limits. This technique is insufficient for the interpretation of the actual state of a surface that has a considerable undulation.
For such a surface we have tried to build up an exhaustive three-dimensional synthesis that has permetted to understand the progress of the floor (Brumana, Crippa, Vassena, 1990), but has introduced a separation from the various aspects of matter and formal of the mosaic.
The knowledge of the state of deterioration and the need to connect it to the geometry and to the structure of the support has defined a preamble to go over this gap. A book or a collection of images has not the potentiality to realize such a link, even if they have a great documentative. To connect it to the geometry of the support it is not sufficient the condition of measurableness, obtained also with the well-known ortoprojection. It is necessary to deform the image on the belonging surface, later projected and visible from different points of view. But it is not enough to make a metrical projection so as to respect a biunique correspondence between the image-point and the corresponding point on the belonging surface.
All this because the level of interpretablness is equally important to identify the condition of deterioration of a mosaical and decorated surface. In particular when this surface is degraded by phenomena of patina, of pulverization and of material incompleteness.

2.1 THE ANALYTICAL APPROACH

The projection of the images of an object on its digital-geometrical shape, obtained by photogrammetry, needs to harmonize and optimize all the different phases of the operation. The images are acquired using metric or semi-metric cameras and are digitalized through a scanner. The angular parameters of the orientation of the camera and thus of the image are defined through a classic operation of absolute orientation. These informations are indispensable to drive, later, the operations of images projection.

INPUT

PHOTOGRAMMETRIC TAKENS

TRADITIONAL CAMERAS

CCD CAMERAS (Frame Grabber)

SCANNER

DIGITAL IMAGE

PHOTOGRAMM-IMAGE RELATIVE ORIENTATION

DTM

MANUAL

SEMIAUTOMATIC

AUTOMATIC

GEOMETRIC SHAPE (by elementary surfaces or microplanes)

INVERSE PROJECTION OF IMAGE ON THE DTM

IMAGE PROJECTION

2D ON BI-DIMENSIONAL SURFACES

3D ON THREE-DIMENSIONAL SURFACES

ON SURFACES PARALLEL TO THE PLANE OF THE IMAGE (plane deformation of the image)

IMAGE ON A GENERIC GEOMETRIC SHAPE a plane image (of a dome) on a sphere.

ON A\ PLANE SURFACE WITH A GENERIC ORIENTATION IN THE SPACE

INFINITESIMAL PART OF THE IMAGE ON THE INFINITESIMAL BELONGING SURFACE

IMAGE ON THE REAL BELONGING SURFACE (plane, curved)

INFINITE NUMBER OF IMAGES ON INFINITE PROJECTIVE PLANES. (Projection on a 3d model of an architecture, of the images belonging at its own architectural object)

The stereoscopic vision of the object permits the definition of a mesh of points with known coordinates. Such coordinates constitue a DTM, that is to say a not continuous description of the shape of the object. Obviously to a greater density of points in the DTM corresponds an higher accuracy of the recostruction of the digital image of the object, seen in its real position in the space (Fig.2).
A greater density of points of the mesh must be accompanied, however, by a contemporary increase of the precision used in determining the coordinates of the points in the space.
Infact it is useless to thicken the meshes of points belonging to the DTM and to reduce the dimensions of the pixels of the image projected if to these operation it is not associated a precision in their definition in the space, certainly smaller of the dimensions of the single pixel.
The achievement of a dense mesh of points defining the DTM is strictly connected with systems of automatic determination of DTM itself. These methods have the good quality to define the spatial coordinates of a great number of points in a short time but imply a lot of problems in the use of photogrammetric takens with critical orientations and in the interpretation of the discontinuities present in the surfaces under study.
In particular when the automatic software meets a sudden change of depth (break lines), it is not able to understand the real thickness without the intervention of an human operator, often not expected in these applications. It must be also considered that such systems of automatic definition of digital terrains are mostly for working in cartography, where the break lines and the sudden change of depth are only occasional (cliffes, precipices..) or present in some application (height of the eaves from the ground).
At present in cartographic field interesting progress in the projection of digital images of the terrain on a DTM have already been developed with the first experiences of the ETH in Zurich.
Once defined the DTM, the shape of the object can be described with a sequence of triangular shaped micro-planes having as vertex three points of the DTM itself.
Fondamentally the projection consists in the operation of projecting on the digital DTM the image of every pixel of the image, that means its tone of grey or color.

Such a kind of projection, with the center of emanation in the front nodal point of the camera and the image placed in the space according to the angular parameters of the external orientation, can create a lot of problems of discontinuity and deformation of the image. For these reason a different method, called 'inverse projection' is preferred. Instead of writing the equation in the space of the line going through the front nodal point O (centre of the optic cone), the pixel P and intersecting the generic micro-plane S, it is preferred to write the equation of the line from the micro-planes to the nodal point. In this way it is granted the complete refilling of the micro-plane of the DTM even if it can't assure the formation of a biunique relationship between pixel-image and its visualisation on the DTM.
Truly said the problem is not solved but avoided. In fact only in presence of a DTM so thick to be considered continuous it is possible to hypothesize a biunique relationship between the pixel-image and every pixel projected on the DTM.
However it is important to remember that such a thickening of the mesh of the DTM is obstructed by important problems of calculation and by the precision with which the position of the points can be evaluated.
As alternative to a thickening of the DTM, even if with different results, there is the possibility to subdivide every micro-plane in different micro-areas. From their barycentre it can be written the same equation of the line going through the front nodal point O too, used in the method of the 'inverse projection'.
This method can help to bring the image projected on the DTM near to the real one, creating more pixel on the image projected in comparaison to the number of those ones belonging to the original digital photogram. In this way it is more granted the continuity of the image but we loose definitively the relation pixel to pixel.
The time of computation and the study of the relationship between density of the DTM - number and dimension of the pixel of the photogram - scale of the photogram - scale of the image projected on the DTM are all together indicating a new direction for the present research. Besides, the solution of these problems is also strictly correlated to the development of new instruments of digital image and computation treatment.
The acquisition of the images with classic photogrammetric cameras can be supported by an acquisition with CCD cameras directly in digital form. In particular the interest is toward the new

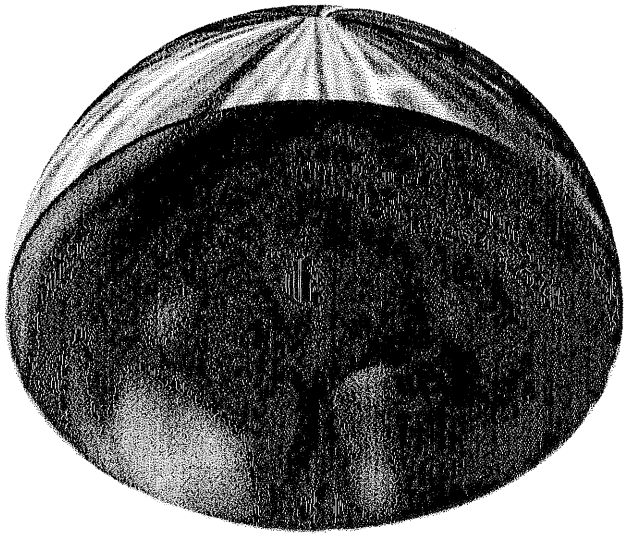

FIG.2 - THE ASCENSIONE'S DOME IN THE ST. MARCUS' BASILICA. THREE-DIMENSIONAL ELABORATION OF THE PHOTOGRAMMETRIC RESTITUTION: THE DIGITAL MODEL HAS BEEN TREATED WITH SOLID MODELLING AND SMOOTHING OF THE ELEMENTARY SURFACES.

FIG.3 - PROJECTION OF THE DIGITAL IMAGE OF THE SPIRITO SANTO'S DOME ON A SPHERE WITH MAPPING PROCESS. THIS IS NOT OBTAINED WITH A RIGOROUSLY ANALYITICAL SOFTWARE BUT WITH A SIMPLY QUALITATIVE ONE.
INFACT THERE ISN'T STILL ANY ALGORITHM AND THE ALGORITHMS ARE THE FINAL POINT OF THE RESEARCH JUST BEGINNED.

THE PROBLEM OF THE IMAGE DEFORMATION ON PLAINS AND SURFACES HAS BEEN REDUCED, WITHOUT CONSIDERING THE ANALYTIC ASPECT, TO THE PROJECTION OF ANY IMAGE ON ANY GEOMETRICAL SHAPE. IT IS SOMETHING LIKE AN IMAGE REFLECTED ON A SOLID. THIS IS THE PROBLEM TO BE SOLVED.

digital cameras that utilize the body of the classical film cameras. They consists of a back that must be added to the classical camera and that permits to register the image directly in the digital form without trasforming it into a video signal.
Anyway at the moment also these instruments (Kodak, Rollei) cannot give a resolution on the acquisition of the images similar to that one given by the system composed by the photogrammetric camera and the scanner.

3 - TO PROJECT AN IMAGE

After the acquisition and memorization of the image the problem still exists of the intervention on it as a deformation that can be considered as a projection. This means to deform the image not only on the plane of the photogram but on each of the infinite planes of projection.
Without considering the analytical aspect, we can reduce the problem to its minimum: the principle is then to think at the projection of a generic image on a surface of generic geometrical shape.
This has, as a consequence the overcoming of the conception of bidimensionality of the image.
It happens a convergence between the disciplinary approach of the conservative intervention on the surfaces and the disciplinary approach on the survey itself.
In fact a relation more and more closer with the third dimension appears. It creates a new bridge between two worlds that, in the history of the restoration, had follow different assumptions and operative choise. The first one of the structures and the second of the surfaces, decorated, plasted, with mosaic...., that too often has been reduced to the images. Infact often the matter, which introduced a great cultural thickness, also physically, is negleted.
Here is the importance to have projected an image of the cupola on the spheric surface (Fig.3). The teorical aspect is underlined, in a strong way for the purpose of a metodology, with the immediate developments and the application in the ambit of cataloguing.

The using of a programm, that doesn't intervene in the analytical problem but manage the projection of images on surfaces, has been the preamble to verify the vision from different points of view of the image. This one regenerates on teh surface projecting then itself on the ideal plane of the video and so of the point of view (Fig.4 Lower part).
What we said becomes essential in presence of surfaces that have hidden points that ask for this operation, to make them usable. These points are present at the same time in the same object but aren't at the same time visible (Fig.4 Upper part). Therefore the research opens new frontiers in the study of the digital images that doesn't involve only the analytic-metric aspect.
The quality of the photogram and of the image represent an essential parameter for their use in a project of conservation. For this reason the possibility to read the phenomena of deterioration, the formal values, and the analysis in general terms have in the photography and in the image the principal reference for the immediate reference to the object that characterize them (Fig.4 Upper part).
An important consideration is about the limit of approaching and of the resolution of the image in relation with the ratio of magnification. The last one is directly proportional to the need of the operator to evaluate the phenomena of alteration and of deterioration and inversely proportional to the need to utilize the traditional scale of representation (1:50) as a limitation of the number of takens referring to the finalities of the drawing to plot.

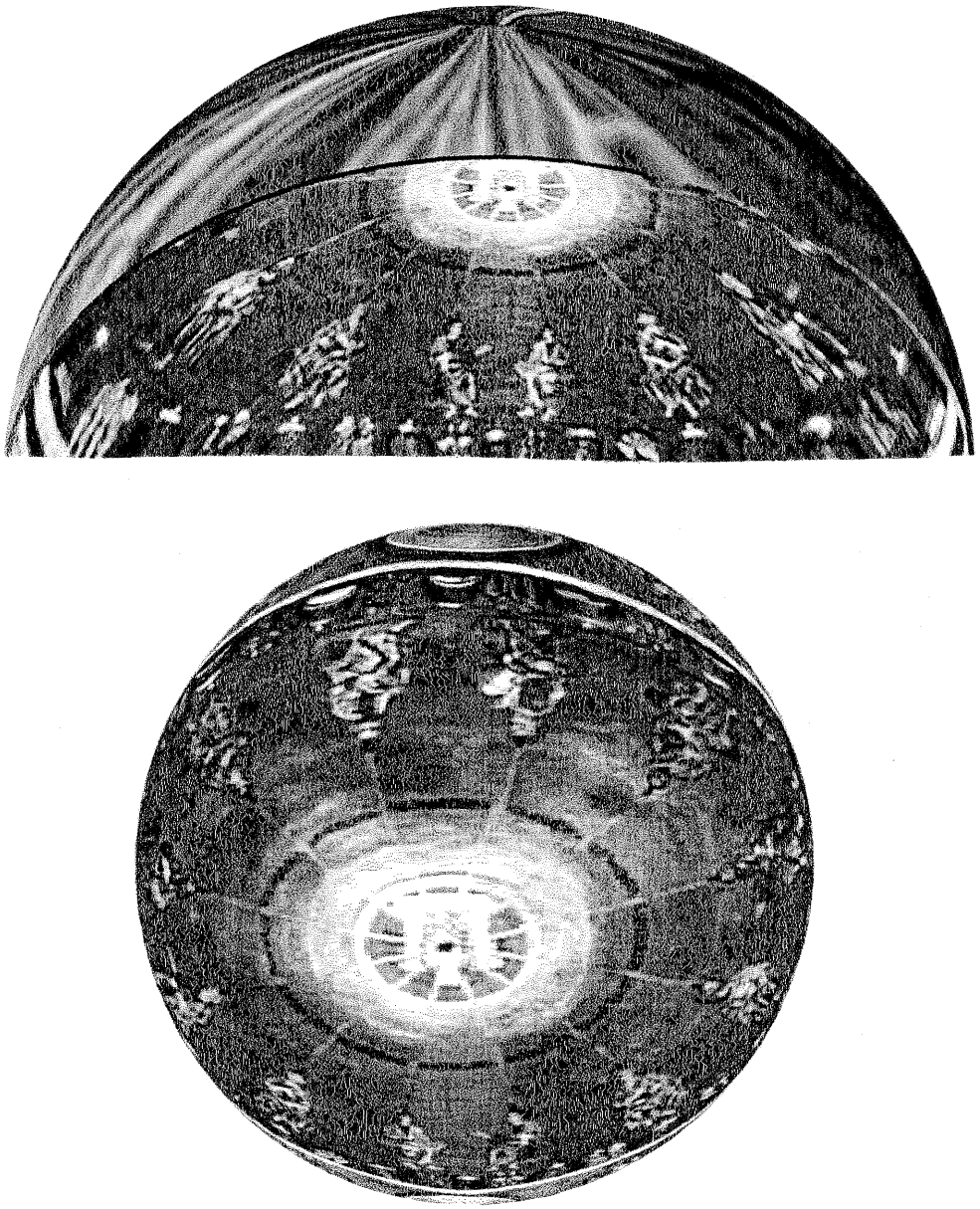

FIG.4 - SPIRITO SANTO'S DOME IN THE ST.MARCUS' BASILICA. THE BEGINNING OF THE RESEARCH: THE IMAGE OF THE DOME IS PROJECTED ON ITS OWN SEMISPHERIC 3D SURFACE. THE RESULT IS PRINTED ON LASER POSCRIPT.
LIKE EXPLAINED IN THE PAPER IT'S NOT REALIZED YET A PROJECTIVE HOMOLOGY BETWEEN ONE POINT ON THE IMAGE AND ITS CORRESPONDING ON THE 3D MODEL (LOWER PART OF THE PICTURE).

THE MOSAICS ARE PROJECTED ON THE INTRADOS OF THE DOME. THE SURFACE HAS BEEN OPACIFIED ON THE EXTRADOS IN ORDER TO OBSCURE THE MOSAICS NOT VISIBLE.
THE PRINCIPLE OF THIS PROCESS IS TO MEMORIZE A GREAT NUMBER OF PHOTOS AND IMAGES AND TO PROJECT THEM ON THEIR OWN SURFACES: IN THE WAY TO VISUALIZE THEMSELVES ON THE DIFFERENT POINTS OF VIEW SELECTED TIME BY TIME (UPPER PART OF THE PICTURE).

4 - PROSPECTS OF APPLICATION IN THE CATALOGUING OF THE IMAGES PROJECTED ON THREE-DIMENSIONAL SURFACES

The high number of takens and the fragmentation of the acquisition of the images (made by a sequence of pictures of the surfaces of the building, of the mosaics, of the bas-rilieves and of frescos) ask that the phase of survey could be made with instrumentations of big handiness.
In particular it is needed an organic project of memorization, organization of archives in the way that could satisfied the needs of cataloguing and fast consultation.
The images are acquired in different sequences depending on the purposes. It is as a film reassembled in different histories
At the end of the cataloguing it becomes important to think at a spatial collocation where to put the images: it means to locate the images in the recreated space of the building (Brumana,1991). In this case the three-dimensional aspect involes not only the single image, that can be imagined, for a moment, bidimensional: for example the internal images of a Basilica must located on the corresponding surfaces (the domes images on the domes, the images of the floor on the floor...) in the way to dress all the body of the church. This operation corresponds in technical terms to a projection made with a number of images.
A catalouguing directly based on the geometry of the object should permit a well done organization, directly reachable by the great number of utilizers in function of the position. It sholud also permit an interesting connection and investigation between the cognitive levels.
The St.Marcus' Basilica is now referred in all its surveies to the National Geographic system. A GIS will allow in the future the availability of the monument in its whole.

This research has been developed using of Fondi MURST 40% 1990/1991

REFERENCES

1. R.BRUMANA, G.GALEAZZO, C.MONTI, E.VIO, "Rilievo e rappresentazione della Basilica di San Marco a Venezia: iconografia storica e attuale per un sistema informativo integrato". Atti del CIPA XII Symposium International de Photogrammetrie Architecturale, Roma 1989.
2. G.GALEAZZO, "Approccio metrico ai grandi organismi architettonici: metodiche analogiche e digitali nei rilievi della Basilica di San Marco a Venezia". Atti del convegno "Componenti architettoniche dell'identita' ambientale: situazione attuale e linee di tendenza", Milano, aprile 1988
3. M.MATTEINI, A.MOLES, "Scienza e restauro - Metodi di indagine", Firenze 1984.
4. R.BRUMANA, "The Hall of the Fountain in the Zisa'palace and the Palatina's chapel in the Norman palace in Palermo. Graph-numerical data bank and image data base to run and use different surveies". Atti del CIPA XII Symposium International de Photogrammetrie Architecturale, Delphi, 2-5 October 1991.
5. R.BRUMANA, B.CRIPPA, G.VASSENA, "Analytical treatment and description of the altimetric check of the St. Marcus' Basilica in Venice", ISPRS Symposium Commission V, Zurich, 3-7 Settembre 1990.