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RECTIFIED IMAGE MEASURING SYSTEM BY ANALYSIS OF PERSPECTIVE FOR OLD CENTERS RESTORATIONS

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1. THE AIM OF RESEARCH

This research belongs to the studies which have been developing by Prof.R.Di Stefano, School of Specialisation on Restoration of monuments, University of Naples, in order to investigate the knowledges and the methodologies for historical cities restorations.

Studies have to provide with a complete documentation oriented to the knowledge and preservation of the historical city, and,therefore, to the consequent activities of city restoring, planning, exploitation and managing.

All data provided with the present documentation will have to be, afterwards, collected in order to to be continuously integrated and made available with accuracy and quickness, making reference to every point of the city, on which it is necessary to develop interventions designing. Hence it follows the great matter to pick out an efficient and suitable informative system. To this purpose, our university pool found very useful the cooperation with Galileo Siscam, and with this latter is setting up a data base alike Gart, which permits to collect data both alphanumerical, graphical and photographic.

It is well known that, in order to have a complete documentation, it is necessary to have town planning, architectural and archaeological surveying, which, obviously, consist not only of whole cartography on the plane.

It is necessary to consider also the third dimension in order to know "site volume", which regards both the natural terrain on which is built and the buildings which form it.

So it is clear that, for documentation and basic knowledges purposes, it is very important to make surveying about ancient iconographical elements collection and "new surveying", which may give a right representation of the exact current shape of every element of the architectural patrimony.

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To these "new surveying" belong developments of facades ("courtains") the roads and the squares and, more generally, the representation of all that defines "the architectural style of a city".

Graphic representations accuracy for restorations purposes, depending from the kind of job to be performed, for the town planning restoration studies and for the singles interventions depending on the methodological part we have to carry out.

It is clear that, for example, at executive level of the project, the surveying of the "courtains" must be very accurate, both in the geometric data and in the representation of every architectural elements.

In the preliminary analysis and general level of the planning can be admissible a low accuracy.

Accuracy limits depending also on artistic and historical values of the zone and on the consequent kind of intervention which is intended to be performed.

To this purpose, in the historical centers, the "protection degrees" were located: GP1, that is buildings of a remarkable monumental value, monumental plants and factories of a remarkable historical-artistic value; GP2, that is buildings of a considerable architectural value which, as a whole, represent very interesting architectural expression forms and which have conserved, inside themselves, very important elements that build up architectural features; GP3, that is buildings belonging to minor Architecture, of acceptable environing, town planning or volumetrically value; GP4, that is building which do not require a particular protection.

To these "protection degrees" correspond the following interventions: to GP1 and GP2, the most rigourous "architectural restoration"; to GP3, "the conservative restoration"; to GP4, "the building reconstruction" or, in some cases, "the building replacement".

A certain approximation, on the dimensional surveying, is admitted but homogeneous in every part of the represented "courtain" and is admitted also a certain difference about the details of the formal drawing of the buildings depending on their protection degree. The surveying of fronts development carried out by means of traditional methodologies or by means of ordinary photogrammetric techniques, is a very hard work from a financial point of view, consequently it has never been possible to perform the surveying of the "courtains", depriving the whole study of a very important investigation tool. There are also many cases where the ratio between road size and heights of buildings doesn't permit to perform any traditional photogrammetric investigation.

In order to try to overcome these difficulties, it has been decided to investigate the experiences, already done somewhere else, to make "developments of fronts" by means of taking sloped photographs after rectifying them, assembling on a mosaic and, finally, representing graphically.

This applied research has been carried out, under the guide of Prof.Ing.Fondelli (Engineering Dept., University of Florence), by a pool where technicians of Architectural Photogrammetry Laboratory (Conservation of Architectural and Environmental Values Dept., University of Naples), together with those ones of Galileo Siscam S.p.A. and Alisud S.p.A. Laboratories, have worked together.

This kind of scientific cooperation permitted to test the possibility (both economical and technical) of new methodology for building courtains surveying within accuracy limits indicated for town planning restorations works.

The first time that the present work was shown, was at the National Naples Congress, at Naples University, Conservation of Architectural and Environmental Values Dept., June 27, 1991.

2.STATE OF THE ART FOR "COURTAINS" SURVEYING

Techniques which use the photograph as a tool for traditional surveying methodologies find always new applications in the architectural field. Photography, which defines "lines" and "areas" of the architectural composition, permits to overcome the limit, (existing in the usual surveying methodologies), to locate only "points", among which lines are laid out. It means that the photograph provides with all the data related to architectural elements.

This representation is obtained from a photograph through instruments and processing which use the rules of Perspective Geometry.

The use of photography is to mention again about the photoplanes, obtained assembling on a base net work a set of aerial rectified and scaled photographs.

It is possible to find a similar use of these photoplanes, in case of building courtains in the historical centers: this use it is already been adopted in some Countries of Central Europe.(FIG.1,2)

In general terms the most used techniques are:

1.stereophotogrammetric data collection

2.photographs rectifying

3.assembling on photoplanes

4.drawing, starting from rectified photographs

5. individualization of many pointson building fronts by analytical photogrammetry.

Drawing scales which are most used are: 1:200 for whole building courtains; 1:100 for partial courtains and 1:50 for particulars.

This methodology was designed over twenty years ago by Hans Foramitti, with a clear reference to the historical centers, where, to take photographs, is necessary to slope a lot the camera station axis because of the dimension of the roads.

In order to use these photographs, it is possible to employ stereophotogrammetry and photographic rectification; in this latter case, it is not theoretically necessary to have stereoscopic photographs. From the beginning this methodology of "photographic surveying" showed itself of a great interest for speed execution and for low costs. It was established, also, that the results were not perfect mainly due to perspective deformations but the obtained image was enough representative of the surveyed monument and gave an accurate information of the conservative conditions of the building.

3. GEOMETRIC FUNDAMENTAL

A contribution to this research can be given starting from the courtains geometry, that shows areas and structural elements nearly flat, and that shows vertical and horizontal outlines (edges, windows, doors, roof eaves, rain pipes, etc.). References elements useful for projective and perspective procedures.

Fast developments of electronic technologies can give also some new solutions, especially when it is possible to employ the digital image processing of the photograph and data collection by Personal Computer. The above techniques are useful in order simplify photograph taken and plotting of the acquired image and, in the meantime, we get photographic and graphic products of a great metric documentary value and of a great qualitative value.

A large number of photographs are hard to be managed, by means of classic methodologies, in order to achieve controlled mosaics and metric graphical representations.

Anyway, consequent processing resulted in a very original form, that consisted of having a raster file by scanner devices, from the collected images, their rectification plottings by means of rectification, their consequent "electronic mosaicking" by equalizing the different used images, the final graphic and bidimensional numeric plot on Personal Computer.

The procedure we used for rectifying was Moebius perspective grid, in order to restore horizontal and vertical elements that were changed by the position of the external orientation elements of the monocamera station.

In Fig.1 it is easy to verify as the perspective could modify itself when normality could restore among different vertical and horizontal lines intersecting themselves in the sloped photograph. The rectifying procedure can be integrated with a compensation algorithm for setting up distances and lengths in horizontal, vertical and sloped direction.

It is clear that the mosaicking can be performed always on Personal Computer, using triangulation methodologies, to ensure the best linkage for the whole set rectified images.

When the photographic assembling of the whole considered courtain is finished, images restoration will have to be performed, if necessary, to obtain a final image of the building. This operation comes out as a preliminary in comparison to the vector plotting and should be performed directly on the same Computer.

Results are still on a experimental basis and so they can be improved.

4.ALGORITHMS FOR RECTIFICATION METHODOLOGY

The "Rectification techniques" normally deform the original image so to eliminate non-parallelism effects of focal plane of the camera and of the object to survey.

Operation limits and analytical instruments costs can strongly condition the use of these techniques in Architecture field. These conditionings can be removed by using electronic technology development computer's field.

Having an image, in a raster form, there are some simple algorithms that permit rectifying operation in a effective way and without particular limits.

Among the points which build up an object plane and the points which build up the image of the same object obtained with a camera, there is a relationship that hang together every point of the object to a point of the image and viceversa. (FIG.4)

By means of this procedure it is possible to rebuild an orthogonal projection starting from whatever camera picture of the object even if very sloped. About the computation of the parameters which defines the transformation, this is done by writing the equations for almost four points of known coordinates on the object and by resolving the equation system that comes from: generally, are known more than the four points strictly necessary: in this case, the minimum least squares adjustment must be applied.

The geometric concept of "point" is replaced by the term "pixel" (picture elements), that is the minimum unit in which the image has been splitted once transformed from analogical to digital. The pixels will be correctly positioned by collineation relationship producing, because of their information content in terms of grey levels, the "orthogonal projection".

The same computer that performs the rectified image provides easily the user with the possibility to perform the graphic plotting and its storing on disc by using a mouse which drives a cursor on the video graphic station. The vectorial information so produced can be obviously used independently from the image or can be associated to it for updating purposes, control or information completeness purposes. The power and the flexibility of a numeric system on executing rectified image are remarkable, It is very important to determine the parameters that define the transformation of the image in another rectified one, and for this determination we need to know the coordinates of some object's points.

To have this known point we have to carry out some measurements by surveying instruments or by very complex and expensive instruments.

In the present algorithm we do not use any known point, but only the horizontal and vertical line position on the photograph to determinate the parameters for "collineation relationship".

Once established rectifying procedures of the perspective image, it's necessary to have the possibility to join the different photoplanes performed to create a mosaic.

This rectifying procedure produces images with homogeneous scaling, so they can be joined to form a single image in a unique reference system, that it's true only if overlaying are guaranteed among images.

Afterwards, it is possible to perform in the complete image some numeric techniques to improve the image, such as grey levels equalization, filtering and so on.

5.FIELD TEST

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In order to verify the real correspondence of the relative accuracy of the obtained drawings compared with tolerance, we did some controls by performing some direct and indirect measurements and by comparing some dimensions on the drawings with those ones corresponding in reality.

Measurements were carried out by using a manual methodology by means of double Invar meter. For the upper zones, by using a theodolite in forward intersections, a series of high points were measured

It was impossible to use Laser distance-meters, as the sloping of the views, necessary in this case, were too excessive.

Coordinates of 25 points distributed in the front under examination were determined and 35 distances among points were measured directly.

The measurements results (direct and indirect) so performed, permitted to find a sufficient amount of distances that were compared with those ones measured directly on the drawings. In general terms, this comparison showed a sufficient correspondence to the precision limits requested and established.

Keep in mind that the current experimental research is addressed to determine a "speedy" work methodology effectively applicable to the environing reality of the historical centers, not claiming to achieve high precision results, as those ones provided by the classic terrestrial photogrammetry methodology and by surveying. It is to point out that the ratio between road size and building height demands an amount of photographs so large to make not proposable photogrammetry plotting data collection.

On the other hand, the rectified methodology we are talking about is not intended to be against the traditional analytical plotting methodologies from a single frame, which without doubts permit more accurate results.

Local operations involve so many troubles that a traditional geometric picture framing, in order to make measurements of the points coordinates, may lead to so high costs to make, practically, impossible the execution. Just in these cases the methodology is useful to satisfy many documentary needs.

The work methodology so improved, makes possible to enlarge fronts surveying to the remarkable amount of building courtains existing in the historical city because it gives great advantages related to costs and to necessary operation times.

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Figura 3

