ANALOGUE AND DIGITAL METHODS IN ARCHITECTURAL PHOTOGRAMMETRY

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ABSTRACT

A description is given of an experience of the survey of the Santuario di S.S. Vittore e Corona in Feltre (province of Belluno, Italy) of the XII century. After having obtained all drawings by traditional methods of surveying and photogrammetry, one has wished to use procedures based on the digitization of the photographic images combined with vector elements. The used computer programs are Orthomap and Archis of Galileo Siscam, running a high end hardware platform, in the environment of personal computers.

Key words: Experience, architectural, orthoprojection, vector data, raster data.

1 INTRODUCTION

The fast developments of software and hardware are stimulating the market with a series of potential applications, also in the photogrammetric field. Most of all, the processing of raster images questions on the possibility of digital photogrammetry. In the field of architecture, and especially in countries with a large architectural heritage like Italy, the use of the metric quality of photogrammetry often remains scarse, caused also by the interpretation, carried out at by the operator during the plotting stage. The possibility to complete the the metric results with a series of qualitative data, which is present in the photographs, can develop the relevance and the usefulness of photogrammetric studies.
Not being experts in informatics, it was decided to acquire experience in the sector by carrying out a series of tests in the field of architecture with digital image processing programs like Orthomap and Archis marketed by Galileo Siscam, and by them kindly made available to us, together with the necessary hardware.
The material, which has been used, had previously been processed with traditional techniques in the framework of an agreement between the Politecnico di Milano and the Sovraintendenza ai Beni Architettonici of the region Veneto to carry out a survey of the Santuario dei S.S. Vittore e Corona at Feltre (Bezoari, Guzzetti, 1992) (Astori, De Vincentis, 1992).
In the following two different experiences are described, of which the first was carried out wit a part of the survey of the sanctuary's interior with the program Orthomap, while the second saw the use of the program Archis for the processing of the photographs taken of the sanctuary's exterior.

2 EXPERIMENTATION WITH THE PROGRAM ORTHOMAP

2.1 The available material

For the described tests a total of six colour photographs have been used, which were taken with a Rollei 6006 camera (format 6x6 cm^2), which correspond to a single view of the sanctuary's interior, and have been used for the assembly of a longitudinal section (fig. 1). Of these photographs, two have been taken in order to carry out controlled rectifications of the walls of the attic, while the other four form two stereocopies of a part of the walls of the interior of the church. For each photograph, a necessary number of control points has been determined.
Still in the framework of the mentioned agreement, after the controlled rectification of the images of the attic, two plots were made of the interior with a Wild BC3 stereoplotter, in order to represent the major architectural lines. Besides, use was made, for the complete assembly of the considered longitudinal section, a survey of the profile obtained by surveying methods using a Wild DIOR 3002.
The phase of surveying for the determination of the points and for the measurement of the sections have been carried out with respect to a principal network, and are therefore referred to a single reference system.
The coordinates of the surveyed points, generated in an Autocad 10 environment, together with the plotting results, have thus given rise to a series of vector based drawings. These, together with the various rectified images, turn out to be the outcome of a traditional survey.
For the described experiment, two D.T.M.'s were created (with a regular grid with a step size of 30 cm), corresponding to two stereo models together the file with breaklines, using the Digicart 40 analytical plotter of Galileo Siscam.

2.2 The program Orthomap

The program Orthomap of Galileo Siscam allows for the realisation of orthoprojections and controlled rectifications from imagery files of the .TIF format, which are converted internally to a suitable format. Currently, image processing is in black and white. A user friendly guiding menu allows for:

a) the capturing of a D.T.M. and corresponding breaklines for the production of an orthophoto;

b) the use of data files relating to necessary ground control points;

c) the use of a procedure for editing of vectors on the imgage, which results from processing;

d) the assembly of mosaics of several processed images;

e) the superimposition on the images of vector data determined in the same reference system;

f) the reprocessing of the images modifying the original grey levels and equalizing them with an approprate editing.

2.3 The scanning of the image

One photograph of each of the two stereo copies and the two images of the attic have been digitized by a scanner, the latter for the realisation of a rectified image. It worth noting at once that it not necessary to have photographs taken perpendicular to the photographed object. For processing with Orthomap, any arbitrary inclination is allowed, even those in beyond the characteristic limits of traditional optical-mechanic rectification and orthophoto

projection. One must however still consider the typical limits of architectural photogrammetry, in which sudden variations in the object's depth are the cause of the fact that small variations in camera position can substantially change the extent of the object's surface, which is visible in the photograph.
The photographs of the interior have a mean scale of about 1:150, because they had to allow for plotting at 1:25. One of the two photographs has been digitizedby a scanner of 2000 dpi (dots per inch) and with a range of 256 grey values, using a CCD camera mounted on the Digicart 40. The size of the corresponding resulting .TIF file resulted to be about 6 Mbyte.
In order to carry out a qualitative comparison of the results, the other photograph has been read at 256 grey level resolution with a commercial scanner of 300 dpi, generating a .TIF file of about 1 Mb.
The two photographs used for the realisation of the rectifications have first been printed in black and white on a 18x18 cm^2 format. Successively, the obtained print has been digitized by a scanner of resolution 300 dpi and 256 grey levels, generating two .TIF files of about 4 Mb each.
The scanning requires a few dozens of seconds for the 300 dpi resolution. All things considered, the data transfer and change of format prior to the actual processing require a much longer time. Already in this situation, it becomes evident that one of the practical problems of such a procedure are the hardware conditions and the characteristics of the network.
It is also worth noting the characteristics of a thus generated images. The representation of both on a videoscreen with a Matrox board driven by a Compaq PC 486 of 50 MHz, does not show large qualitative differences between the various images. When the analysis is repeated after having carried out a series of zooms, considerable differences between the 300 dpi and 2000 dpi resolution become obviously evident.
Galileo Siscam is already developing software which allows for the use of the characteristics of the grid of 11 x 11 reseau crosses, which are present on every photograph taken with the Rollei 6006, in order to allow for the correction of deformations introduced during a possible printing, those of the paper support and those introduced by the scanner, as if the total effect were generated by a normal distortion.

2.4 Processing by Orthomap

The processing by the scanner is called by the orthoprojection program with the D.T.M. and the corresponding breaklines, after having identified the characteristics of the camera and having identified the control points with the mouse.
A large question mark arises in this phase: while breaklines in aerial photogrammetry are easily identifiable elements, in the architectural field they become a partly anomalous element. They can not always be plotted because often they are not visible on one of the photographs, or on both. For example, a window still must be represented by two three dimensional elements, more or less coinciding in the view, indicating respectively the beginning and the end of the mentioned still. From experience one can say that normally only one of the lines can be plotted. It is like as if in aerial photogrammetry one would have to plot both the eaves and the ground line of buildings, without considering that the relative depth variations in architectural photogrammetry are usually much larger.
The white areas of the plot are necessarily also present in the D.T.M.; there will be parts of the image without corresponding 3-D objects, which have known coordinates. For these areas, the orthoprojection will be erroneous, or, at best, ill determinated, if one does not edit the file of the plotted breaklines generating the corresponding lines.
Apart from this, the program runs sufficiently fast on a hardware platforms as that, which was used.
Figure 2 shows the orthoprojection of the image digitized at 300 dpi, processed without using the breaklines, with

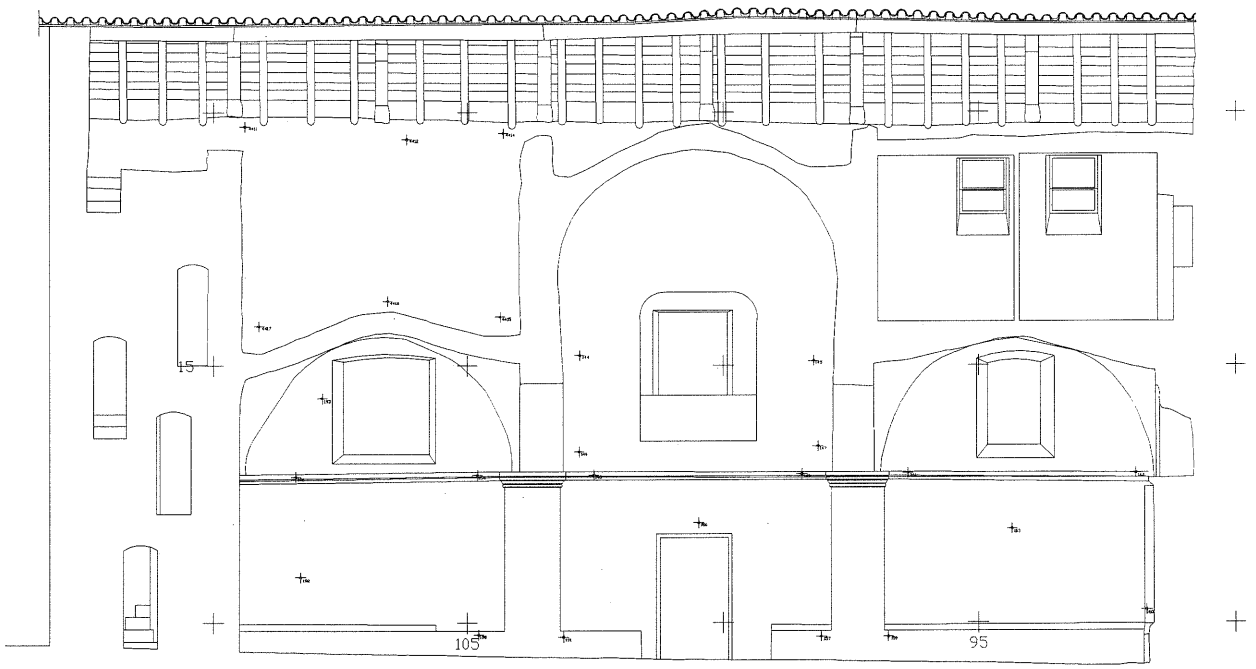

Figure 1 - A longitudinal section of the Santuario.

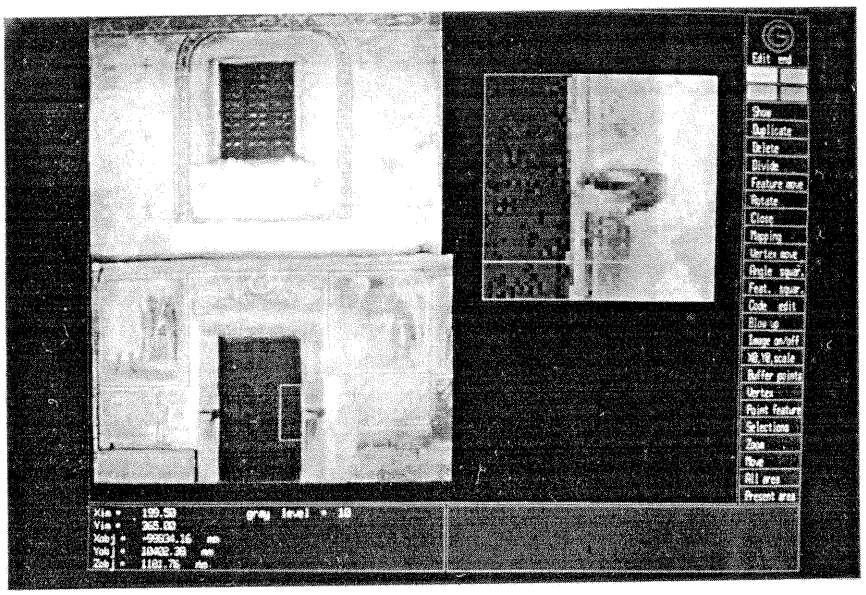

Figure 2 - Orthoproiection of the image digitized at 300 dpi, processed without using breaklines.

the zoom of a detail. Figure 3 shows the orthoprojection of an image digitized at 2000 dpi and processed with the help of breaklines, with a zoom on a detail with the same degree of enlargement as the previous. The differences are beginning to become clear.
On the other hand, the two photographs of the attic have been rectified with 4 control points each. Successively, one has assembled a mosaic of each photograph with the rest of the view, without equalisation of the images and without softening the chromatic junctions. Figure 4 shows all three operations (rectified photos and two orthoprojections) superimposed on the known vector data, derived from the surveyed cross section and from the geometric lines obtained by photogrammetric plotting. From an analysis of the residuals on signalized points, both on the orthophotos and the rectified images, values are found in the order of 5 mm.
The procedure has a high degree of automation. The memory requirements become important. The file of the generated combination has a size of about 15 Mb.
From the figure one can already see how the attic images (printed three times enlarged and digitized at 300 dpi) have characteristics, which are more than sufficient for a series of possible applications. Not sufficient however is the digitizing at 300 dpi of the negative of the orthoprojected photograph. Excellent and maybe exuberant in definition is the resolution of the photograph read at 2000 dpi.

2.5 Metric considerations

One must remind first of all that, in orthoprojections, each pixel maintains the three dimensional characteristics of the object, while in rectified images, which obviously are two dimensional, one looses the information with respect to depth.

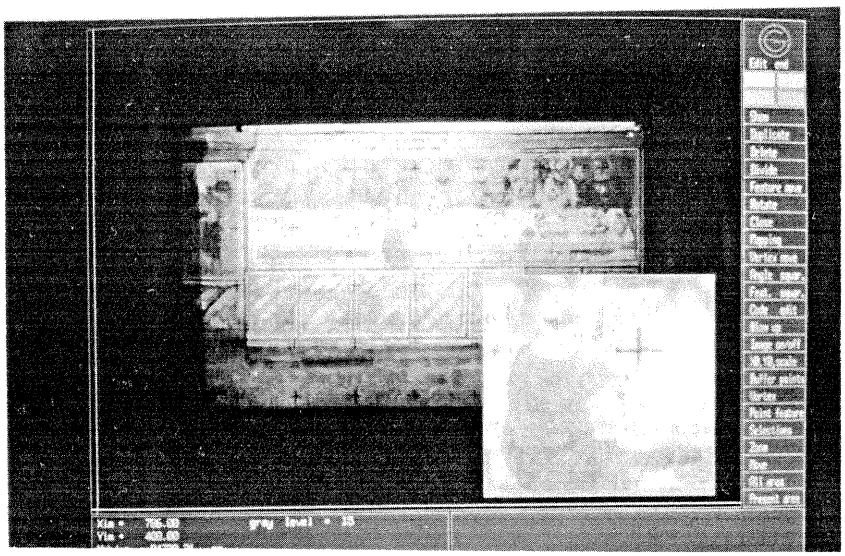

Figure 3 - Orthoproiection of the image digitized at 2000 dpi, processed with the help of breaklines.

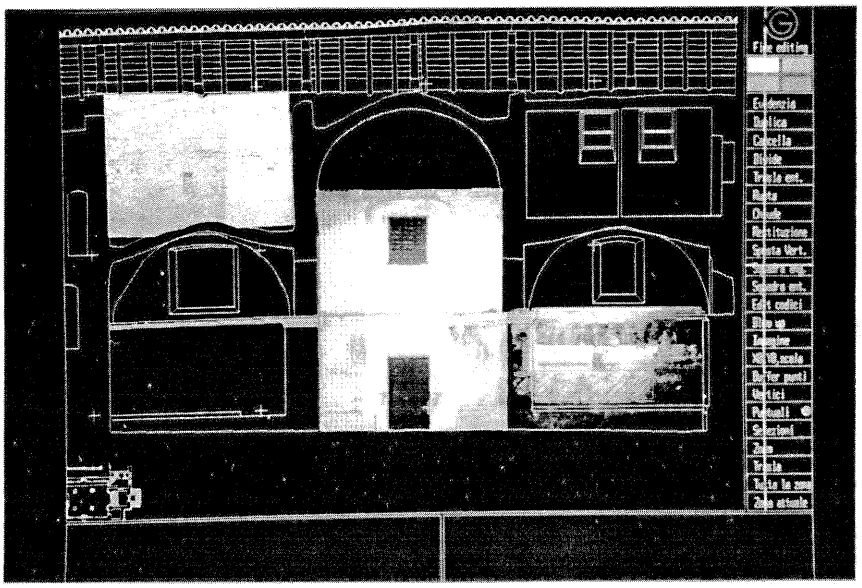

Figure 4 - Rectifed photos and orthoproiections superimposed on the known vector data.

The orthophoto projection program resolves with practically identical residuals at the control points both the photograph digitized at 300 dpi and that of 2000 dpi.
Much more evident, from the metric point of view, are the effects of using or not using breaklines; it is not possible to consider not using them and rather the previously discussed problems, regarding their generation in architectural photogrammetry would deserve a more profound study to find a suitable solution for the general case of an arbitrary viewing condition and an arbitrary object.
The metric characteristics remain however correlated according to the normal photogrammetric logic, to the mean scale of the photograph, the focal length of the camera, the size of the photograph and on the baselength of the stereo copy. Considering the memory requirement problems with digital imagery, obtained by scanning at 2000 dpi, and the their esuberance in definition, one has to ask oneself wether it would not be more convenient to work with a smaller scale, with respect to those used in the survey, for the processing of photographs with the previously decribed raster analysis. This consideration becomes more realistic when the deformations, introduced after the photograph was taken, are corrected with the help of the grid of crosses included in the camera. The subject deserves a systematic study in close correlation with the characteristics of the available hardware and software.
At this point it may be appropriate to make the following consideration. The level of scanning necessary in order to be able to define the used metric pixel for example for autocorrelation of images is esuberant if the metric characteristics are guaranteed by the D.T.M. and the pixel is only used to transform the qualitative information of the photograph.

2.6 The plots

In our opinion, the stage of output on plotter is the part, where the limits of the current hardware are met and where (which is equivalent) costs are a major factor.
The first large limitation is the number of different grey levels, which are reproduced in the plotting stage. This number is at least four times smaller than the 256 grey levels obtained during digitizing, even when using a thermic printer. This characteristic is very selective in the field of architecture where the contours of the object are only a part of the final result. Results of sufficient quality (with respect to traditional orthophotos and rectifications) using an Iris Inkjet 6024.
Anyway, for output on paper, the number of grey levels in plotting has a larger influence on the result than the resolution in scanning. In fact, even the printing of an area scanned at 2000 dpi has characteristics, which make it unacceptable with respect to normal products of typical working products of the architectural environment.

2.7 Conclusions

Because of the rapid developments of hardware and software, even an expert is at the mercy of the market of informatics and every statement can be outdated in a short time.
This is however not the reason, which urges us to state that elaborations obtained from scanned photographs and successively orthoprojected and rectified with overlaying of vector data can be extremely useful to architecture.
In our opinion, the most important result of the present research is, at least for the moment ????. The weak part of the three dimensional processing of images remains the output on paper, also from the point of view of metric precision.
It could therefore be intelligent to have a different relation with the user of a photogrammetric survey. One does not have to supply a plot, but, once familiar with its use, provide a computer based copy of the orthoprojection and / or the rectification, which is easy to manipulate with software. The user can then take advantage of the characteristics of digital images and elaborate grey levels; he can equalize the images; he can carry out ad hoc vector based operations and possibly print them on paper, without running into problems in connection with plotter characteristics, having only to print only lines and hatched areas. An example can be the following: an art historian, using the result of an orthoprojection of a wall of bricks, wants to study the stucture of the wall. Once the grey values corresponding to the fugues between the bricks have been identified, the fugues can be highlighted and the intensity of the other grey valuescan simultaneously be lowered. On the video screen appears only the fugue structure. By entering in editing in these conditions, he can create a vector based drawing on a suitable layer, which can be processed separately and which maintains the metric quality of the orthoprojection.
From this point of view, an experiment is being carried out with a restorer of a fresco of the Zavattari's in the Chapel of Queen Teodolinda in Monza's Cathedral, to verify the applicability of photogrammetry to the field of architecture.

3 EXPERIMENTS WITH THE PROGRAM ARCHIS

3.1 The available material

For the described tests four colour photographs were used, which were taken with a Rollei 6006 camera and cover the sanctuary's exterior. These photographs, together with others not used in the test, have been used for the plotting of views of the exterior with the Wild BC3 stereoplotter and with the Wild Elcovision system (fig. 5). Three of the photographs are not taken perpendicular to the photographed wall. The coordinates of 19 points are known, they were determined by surveying methods and used with succes for the above mentioned plottings.

3.2 The program Archis

The program Archis is based on a reconstruction of the geometric conditions of the view. In every text on designing one meets the scheme of definition of the view of a building photographed under a certain angle, once graphically redetermined the vanishing points of the view and after having scaled some element.
Archis is therefore not a rigorous program; the aim of such a software is that of solving in a simplified way a series of problems for cases in which the geometries adjacent to the imaged object are narrow, and where a high plotting precision is not necessary. These conditions are often present in the medieval centres of Italian towns. Generally it is very difficult to carry out a fast survey of views of closely built houses in narrow alleys. Often the result is that the survey is carried out using only proportions and completion of the designs with drawing on the spot.

Archis however allows for a simplifyed rectification of the photographed image, after it has be digitized. Considering the degree of simplification of the problem, an arbitrary camera can be chosen for the survey.
After having carried out the approximate rectification, the image must be scaled. For this, it is sufficient to know the ratio between two elements of which one is inclined horizontally and one vertically. Also in this stage the degree of approximation can be considerable. If desired, it is possible to use several distances to improve the metric qualities of the result.
After having completed the operation, the image can be combined with another in a mosaic, using common elements of both images: on the mosaic one can finally use a normal editing of vector data like to drawing lines and contouring elements and so obtain a sort of plot.

3.3 The test carried out and the results

The photographs of format 6x6 cm^2 have been printed in black and white on a 18x18 cm^2 format. These prints have been digitized by a scanner of 200 dpi. In total, the four .TIF files require about 14 Mb.
One at the time, on each of the them, one must identify, with the help of a simple guiding menu, horizontal and vertical lines in order to determine analitically the position of the vansihing points of the perspective view. An index gives evidence of the goodness of the determination which was carried out, which is obviously based on a digitalization with a mouse of well pointable elements which are with good approximation vertical or horizontal.

Figure 5 - The plotting of views of the exterior with the Wild Elcovision system.

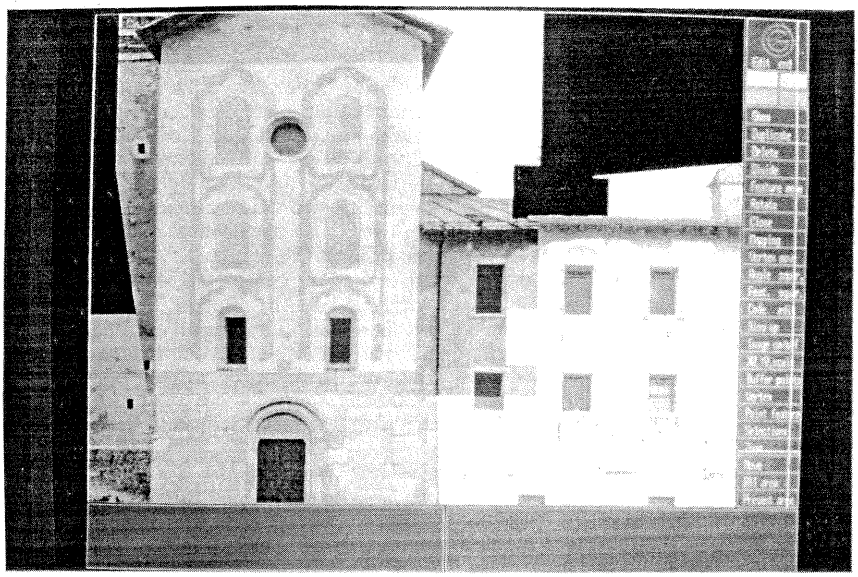

Figure 6 - The rectifications assembled in a mosaic with program Archis.

When the vanishing point is not at infinity one must extend the procedure by defining or the position of the principle point (obviously approximately, by digitizing the four edges of the image), or the ratio between a horizontal and a vertical linear elements, or finally, by providing a given angle between two distinct lines in the image. After having activated the conclusive procedure, in a few seconds the rectified image appears on the screen.
The four images used have been rectified without absolutely taking into account of the fact that they had been taken with a metric camera.
The rectifications have then been assembled in a mosaic in order to obtain the perspective view, which is partially shown in figure 6. The final file has a size of about 12 Mb.
The final image has then been scaled using the given distance between two of the 19 control points. As a metric test one has checked the residuals on the other points after the operation: these resulted sometimes to be larger than 10 cm. This result is, as forseen, not very significant, regarding the precision.
With the mosaic of rectified images a number of test have been carried out with respect to the possibilities of vector editing and editing of the image itself by changing intensities, the cutting of an image along lines and the improvement of the areas of overlap between the images.

3.4 Conclusions

The result does not have the metric characteristics of even semplified photogrammetric procedures. It can however be useful for a series of operations, which often lead to the necessity to carry out a survey of a view. In our opinion it is certainly better to have a product like that obtained with Archis than that, which one often obtains from an inorganic composition of direct measurements, photographs and representations on the spot.
It is a very important fact that the final result contains all information of the photograph and is not a summary of only few lines. Processing of vector data can still and always take place.
An other fundamentally large potential consists of the fact that the use is required of normal amateur cameras. Besides, control points are not required; for the scaling of the rectified image is is sufficient to know a few distances between points.
The defects of a software like Archis are in the simplicity of its use. If the determination of the vanishing point is not carried out correctly, one risks to distort significantly the quality of the results from the geometric point of view. The approximations are quite allowed when the object is plane. All deviations from planarity of the surveyed wall are translated in ever worse approximations with respect to reality.

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