ARCHITECTURAL PHOTOGRAMMETRY WITH THE TIPHON SOFTWARE TOWARDS DIGITAL DOCUMENTATION IN THE FIELD

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ABSTRACT

The paper presents the **TIPHON** software (**T**raitement d'**I**mage et **PHO**togrammétrie **N**umérique) developed at the Ecole Nationale Supérieure des Arts et Industries de Strasbourg (ENSAIS, Polytechnicum of Strasbourg, France). TIPHON is a Windows 95 application and allows terrestrial and aerial stereophotogrammetry with different kinds of cameras (cameras with fiducial marks, réseau cameras, non metric calibrated cameras). The measurements on the images are manual or semi-automatic by correlation. The automatic measurement by correlation modifies the way of stereoplotting and many plottings in architectural photogrammetry can be produced just by measuring accurately on only one image of the stereopair. The stereoplotting of points and lines is directly superimposed on the images on the screen. Some examples of digital architectural documentation on historic monuments in Egypt, France and Morocco are presented. A digital fieldwork with a FUJIX DS-300 digital camera and the possibility to start the drawings in the field with the TIPHON software installed on a notebook is also described.

RESUME

L'article présente le logiciel **TIPHON** (**T**raitement d'**I**mage et **PHO**togrammétrie **N**umérique) développé à l'Ecole Nationale Supérieure des Arts et Industries de Strasbourg (ENSAIS, Polytechnicum de Strasbourg, France). TIPHON fonctionne sous Windows 95 et peut être utilisé pour la stéréophotogrammétrie aérienne et terrestre quel que soit le type de chambre de prise de vues (chambres avec repères de fond de chambre, chambres avec réseau, chambres d'amateur étalonnées). Les pointés sur les images numériques sont manuels ou semi-automatiques par corrélation d'images. La mesure automatique par corrélation d'images modifie les méthodes de stéréorestitution et de nombreux travaux en photogrammétrie architecturale peuvent être réalisés en ne pointant avec précision que sur une des deux images du couple stéréoscopique. Les points et lignes restituées sont directement superposables aux images sur l'écran. Quelques exemples de photogrammétrie architecturale réalisés sur des monuments historiques en Egypte, en France et au Maroc sont présentés. Un relevé avec une caméra numérique FUJIX DS-300 présente les possibilités d'aborder la restitution directement sur le terrain en utilisant TIPHON sur un ordinateur portable.

ZUSAMMENFASSUNG

Dieser Aufsatz stellt das Softwarepaket **TIPHON** (**T**raitement d'**I**mage et **PHO**togrammétrie **N**umérique), das an der ENSAIS (Ecole Nationale Supérieure des Arts et Industries de Strasbourg, Polytechnicum von Strasbourg, Frankreich) entwickelt wird, vor. TIPHON läuft unter dem Windows95 Betriebssystem und handelt mit terrestrische oder Luftbildphotogrammetrie mit allen Arten von Kameras (Kameras mit Rahmenmarken, mit Reseau, Amateurmeßkameras). Die Digitalisierung von Bildpunkten ist entweder manuel oder semi-automatisch durch Bildpunktkorrelation durchgeführt. Die automatische Digitalisierung ändert die Art und Weise wie die Messungen in Stereopaaren fortgeführt werden. Wer solche Korrelationsalgoritmen verwendet, kann in Architekturphotogrammetrie z.B. viele Arbeiten mit einer präzisen Einbildmessung erledigen. Ausgewertete Punkte und Linien sind in den Bildern am Bildschirm direkt eingespiegelt. Mehrere Beispiele aus dem Bereich Architekturphotogrammetrie und historische Monumente aus Ägypten, Frankreich und Marocco werden dargestellt. Die Perspektive mit einer digitalen Kamera FUJIX DS-300 und mit TIPHON auf einem Laptop zu arbeiten, erlaubt direkte Feldauswertungen zu erwarten.

1. INTRODUCTION

Photogrammetry is well known in practice for surveying historical monuments and sites but quite often this science is synonymous with big investment. Commercial photogrammetric analytical or digital stereoplotting systems are generally expensive, sophisticated and not available for architects, historians, archeologists, conservationists and inventory experts. The paper presents a simple photogrammetric PC-system called **TIPHON** (**T**raitement d'**I**mage et **PHO**togrammétrie **N**umérique) developed by the group "Photogrammetry and Geomatics" at ENSAIS Strasbourg. This software was at first designed for teaching the practice of photogrammetry (Morot, Grussenmeyer, 1996) to the students of the Department of Surveying. We try to show in this paper that TIPHON is appropriate for the needs of mass restitution and low cost documentation in architectural photogrammetry.

2. PRESENTATION OF THE TIPHON SOFTWARE

2.1 Main features

The software is based on the well known routines of the stereomodel compilation in photogrammetry (Albertz, 1989 ; Kraus, 1994).
Digital images are obtained by photogrammetric scanners (photoscan PS1 of Zeiss for example) or with the Kodak CD Photo Process for small and medium format slides. For simple and non accurate applications, standard photoscanners (AGFA Arcus II device for example) can be used for the digitizing. New CCD cameras technologies are also suitable for photogrammetry and an exemple with a FUJIX DS-300 camera is outlined at the end of the paper.
TIPHON works on every kind of computer with Windows 95. A low cost Pentium 133Mhz is sufficient for small format applications (for example with a stereopair of two black and white images of 5 Mb each). With the increasing power of computer science technology, digital photogrammetry is more and more possible at a low cost.
Compared to analytical photogrammetry, the use of digital images allows automatic measurements. The correlation process is a plus point for the measurement with TIPHON at each step of the photogrammetric process (inner and outer orientation). The measurement by correlation modifies the way of stereoplotting and many plottings in architectural photogrammetry can be produced just by measuring accurately on only one image of the stereopair.

2.2 Data management of the stereopair

The software creates a text file with all the measured and computed data for each step of the orientation (preparation of the project and the model, orientation of the model, map compilation).

Creation of the project :
The file "project_name.pro" contains the user information, the project information, and the tolerances for the project.

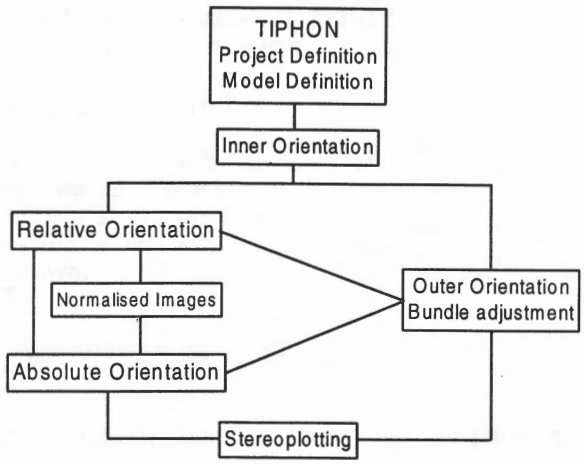

Figure 1 : management of the stereopair with TIPHON

Creation of the Model :
The file "model_name.mod" contains the name of the image (black and white) files (bmp format), the control point file and the camera file. The camera file contains the coordinates of the fiducial marks, the principal distance, the coordinates of the principal point and the radial distortion parameters.

For the orientation of the stereomodel, several files are created :
- File "model_name.int" (inner orientation results)
- File "model_name.rel" (relative orientation results)
- File "model_name.abs" (outer orientation results, single-step or two-step orientation)
- File "model_name.mes" (new measured points in object-coordinates X,Y,Z)
- File "model_name.dxf" (compiled map in DXF format)

2.3 Image management

TIPHON can be used with two different screen settings : the 1024x768 pixels resolution which is standard for personal computers, or 800x600 pixels resolution when the software is implemented on a notebook.

The user can choose two different methods for pointing on the screen :
- the standard well known mode, i.e. the image is fixed and the cursor can move on it
- a second mode better designed for 3D viewing, with a fixed cursor related to the moving image. When the mouse is moved, the image moves too.

With the zoom, the user enlarges or reduces the two images of the model with the same factor. The minimum factor is obtained when the image is included in the window display. The use of the zoom in and out function is practically unlimited. Each image is centered in its window on the point used for the zoom.

A point measured in an earlier step can be automatically pointed again by a simple double-click in the dialogue box. The user can also modify the shape and the colour of the floating mark to adapt his measure to the different objects in the image.

2.4 Correlation

In digital photogrammetry most of the measurements can be done automatically by correlation. The task is to find the position of a geometric figure (called reference matrix) in a digital image. If the approximate position of the reference matrix in the image is known, then we can define a so-called search matrix. Correlation computations are used to determine the required position in the digital image. By correlation in the subpixel range (Kraus, 1994 ; Höhle, 1997), the accuracy of positioning is roughly one order of magnitude better than the pixel size.

In the TIPHON software, correlation in the subpixel range is implemented in the different steps of the orientation. Fiducial marks or réseau crosses can be measured automatically in the inner orientation. Homologous points are measured by correlation in the relative and absolute orientation, as well as in the stereoplotting module. In this case an area (chosen by the user in the left or right image) is used as target matrix.

The size of the reference and search matrix can be defined by the user (7x7 pixels to 20x20 pixels). During the inner orientation, the reference matrix for the correlation on the reseau of the image is defined by measuring crosses in the image (left window with the measured grey values, fig. 2) or artificially (right window, fig.2).

The correlation function is real progress compared with the manual measurements applied in analytical photogrammetry. An important part of the stereoplotting can be done without stereoscopic observation. The quality of the measurement is given by the correlation factor.

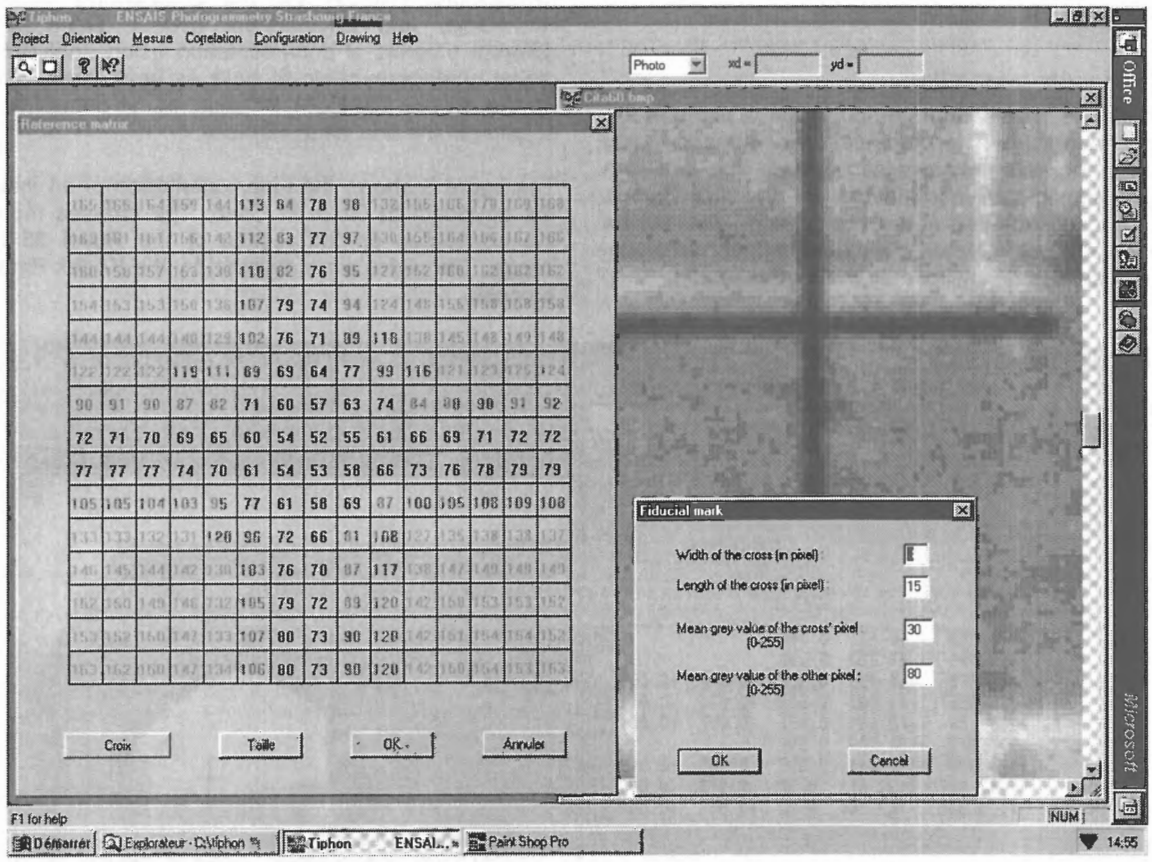

Figure 2 : definition of the target matrix (here a cross of a reseau) in the correlation menu of TIPHON

2.5 Compilation of the stereomodel

2.5.1 The inner orientation

A plane affine transformation with overdetermination is currently used for the inner orientation. The fiducials marks (or the reseau) measured on the images will allow the user to take the deformations due to the scanning process into account. The photo-coordinates are defined after correcting the radial distortions given by the camera file.

2.5.2 The relative orientation

The measure of homologous pairs of points is achieved manually or semiautomatically by correlation in pseudostereoscopic conditions :
- a point or an area is chosen in the left (or right) image
- the homologous point or area is approximately indicated on the other image
- the final point is computed by correlation.

The relative orientation of independent photo pairs is based on the coplanarity condition (Albertz, 1989). The definition of the approximate orientation elements is

made possible by the user in a dialogue box. At this step, TIPHON is a digital stereoscope.

2.5.3 Production of normalised images

After the relative orientation, the two original images can be processed into normalised images. The mathematical equations (Kraus, 1994) between a pixel in the original image and its homologous one in the corresponding normalised image are derived from the collinearity conditions.
In TIPHON, the density of the transformed centre pixel in the normalised image is currently based on the nearest neighbour process. If no precise area in the image is defined by the user, the software computes the whole area of the image into a normalised image. The correction due to the radial distortions of the objective are included in this process. The user is able to work either on the original or on the normalised images. There is a compatibility between the two types of images for further processing.

2.5.4 The outer orientation

The model is afterwards computed to complete the absolute orientation. The computation is stopped if any problem in the automatic process occurs. The user can specify approximated coordinates for the adjustment. The common orientation of the two photographs can be achieved with a single step bundle adjustment or a two-step procedure (spatial similarity transformation).

When the outer orientation is completed, the stereoplotting is possible. The correlation function simplifies the data capture. For special measurements, a stereoscopic viewer can be added to the computer's screen. The measured points and lines are recorded in a compatible DXF file or directly send to Microstation by a specific routine.

3. EXPERIENCES IN ARCHITECTURAL PHOTOGRAMMETRY WITH TIPHON

3.1 Documentation of the Aqueduct El Ghuri in Cairo (Egypt)

The TIPHON software was used in 1997 for the training of Egyptian civil engineers in the field of architectural photogrammetry (Grussenmeyer, Abdallah, 1997). In the frame of the cooperation program between ENSAIS (Strasbourg, France) and the Engineering Center for Archeology and Environment (ECAE, Cairo, Egypt), different projects of documentation using analytical and digital photogrammetric techniques have been initiated. At the ECAE, TIPHON is used as a complementary solution to the analytical methods.

The figure 3 shows the inner orientation of an image of the aqueduct El Ghuri in Cairo. The crosses represent the correlation on the reseau of the Rollei 35 Metric image. The slides were digitized by the Kodak Photo CD process.

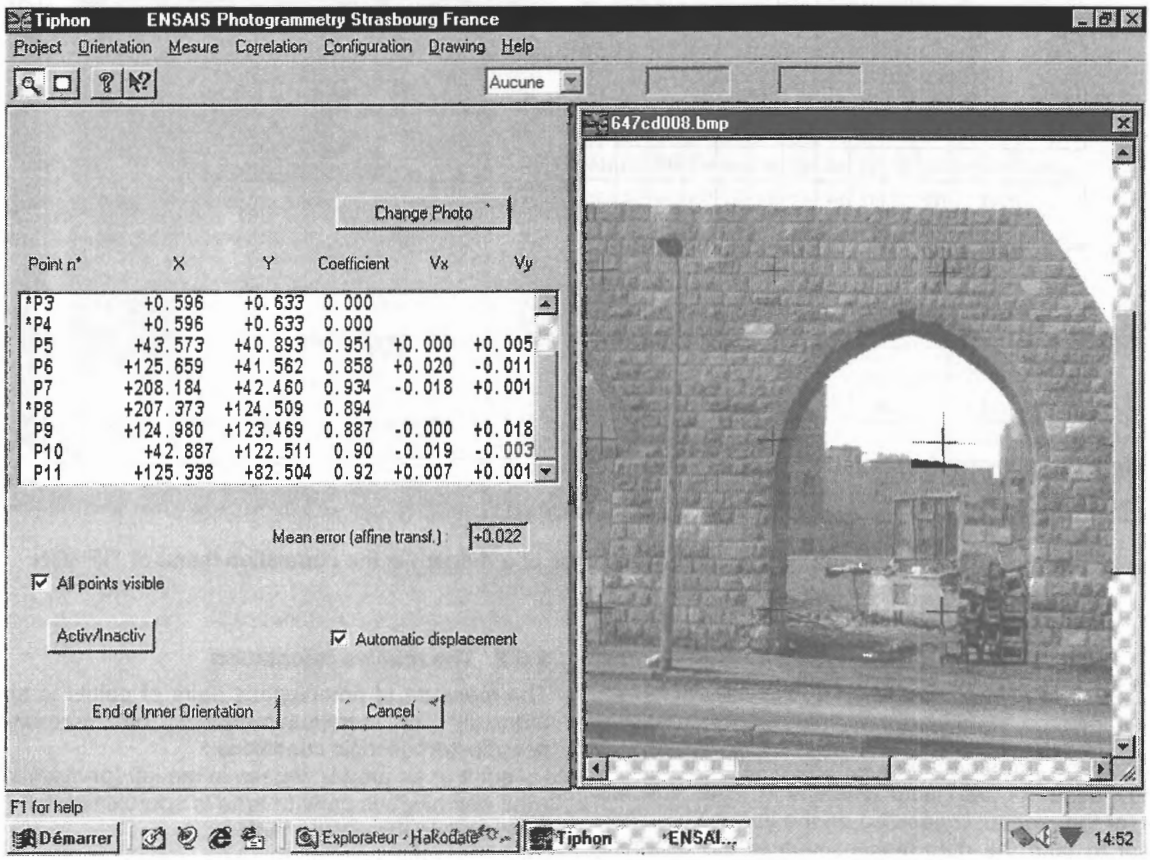

Figure 3 : the dialogue box of the inner orientation with TIPHON

3.2 The survey of the Medersa Bouinaniya in the Medina of Fes (Morocco)

The Medina of Fes in Morocco is classified as worldwide heritage by UNESCO. But there is no updated documentation of its monuments. The Agency for Disdensification and Rehabilitation of the Medina of Fes (ADER-Fes) has been created to bring into operation the safeguarding project of this town. The study undertaken by (Benmlih, Grussenmeyer, 1995) integrates an experimental project aiming, firstly, at analysing the ADER problems in the field of the restoration of historical monuments. The methods used for the survey are still manual and the difficulty in obtaining a complete elevation is due to the dimension as well as to the complex and subtle ornamentation of the monuments. By a restitution of the Medersa Bouinaniya, we display the aptitude of photogrammetry for representing this architecture, complex as it may be.
Different photogrammetric methods were presented to the ADER in 95. The Figure 5 shows the menu of the relative orientation with TIPHON applied on a stereopair of small format RICOH KR1OM slides. The dialogue box indicates the photo-coordinates, the correlation coefficient, the residuals and the required orientation elements. Low cost digital photogrammetry is a solution for the documentation of complex architectures.

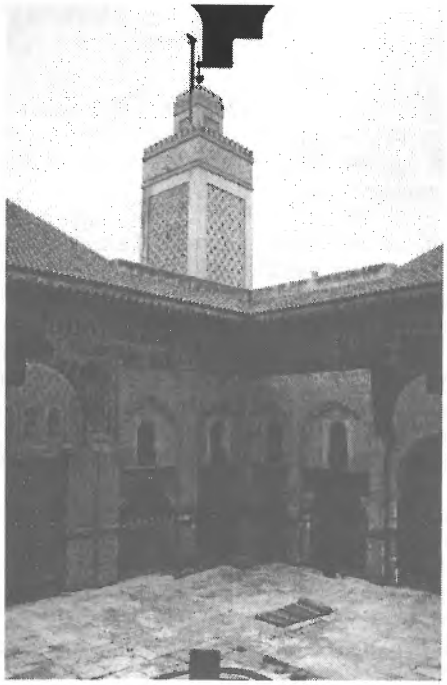

Figure 4 : overall view of the courtyard of the Medersa Bouinaniya in the Medina of Fes

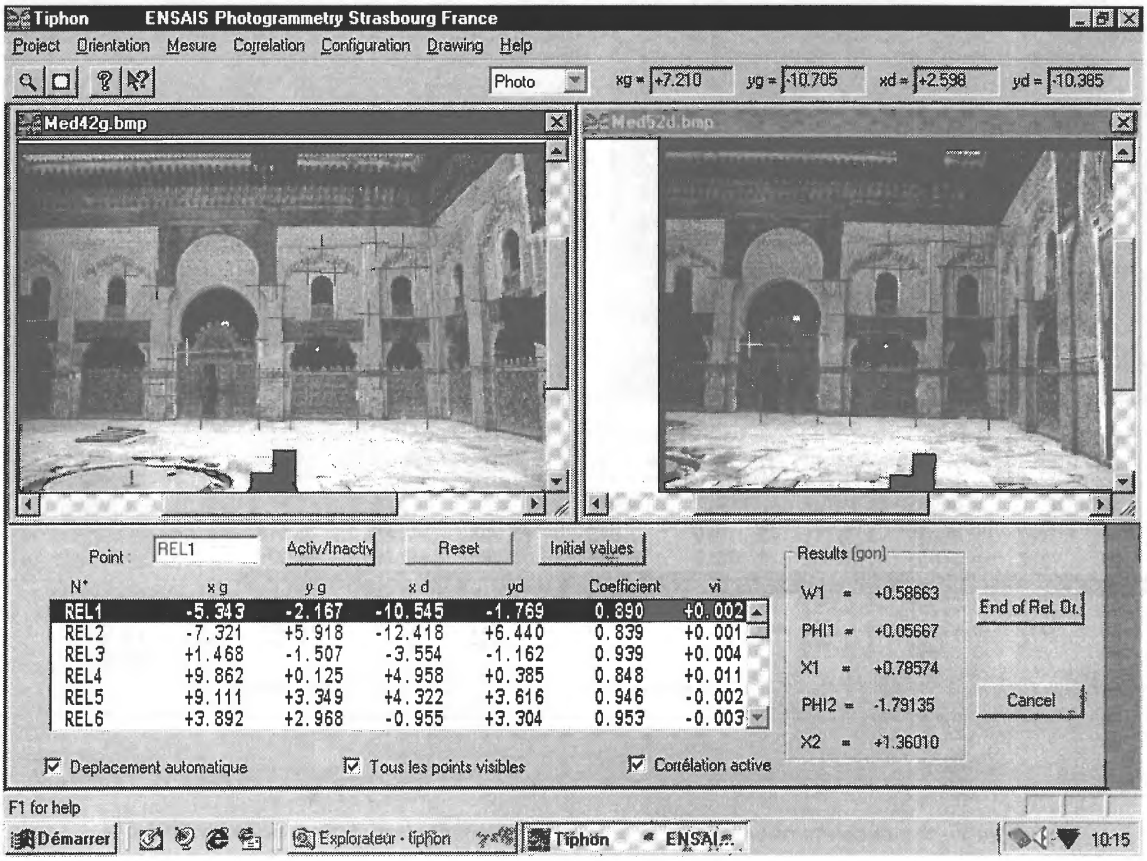

Figure 5 : the relative orientation with TIPHON.

3.3 The survey of paintings at the Unterlinden Museum in Colmar (France)

The aim of this project was to control the distortion of a panel from the altarpiece of Issenheim (oil on wood painting of approx. 2.7 x 4 m) exposed in the chapel of the Unterlinden's museum in Colmar (France).

Surveys in winter and summer were compared to estimate the deformations due to the differences of temperature and damp. The measures of the Wild P32 stereopairs were carried out by analytical techniques on a Zeiss Planicomp in stereocomparator mode. The images were also digitized with a Zeiss PS1 scanner to allow digital work with TIPHON. This example shows again that digital measuring by correlation is a very interesting progress compared to analytical techniques.

The Figure 7 shows the menu of the absolute orientation with TIPHON applied to a stereopair of medium format Wild P32 slides. The dialogue box indicates the model-coordinates, the correlation coefficient for each measured point, the control points residuals (in mm in this example) and the required orientation elements.

Figure 6 : overall view of the crucifixion panel of Matthias Grünewald (altarpiece of Issenheim at the Unterlinden's Museum in Colmar, France).

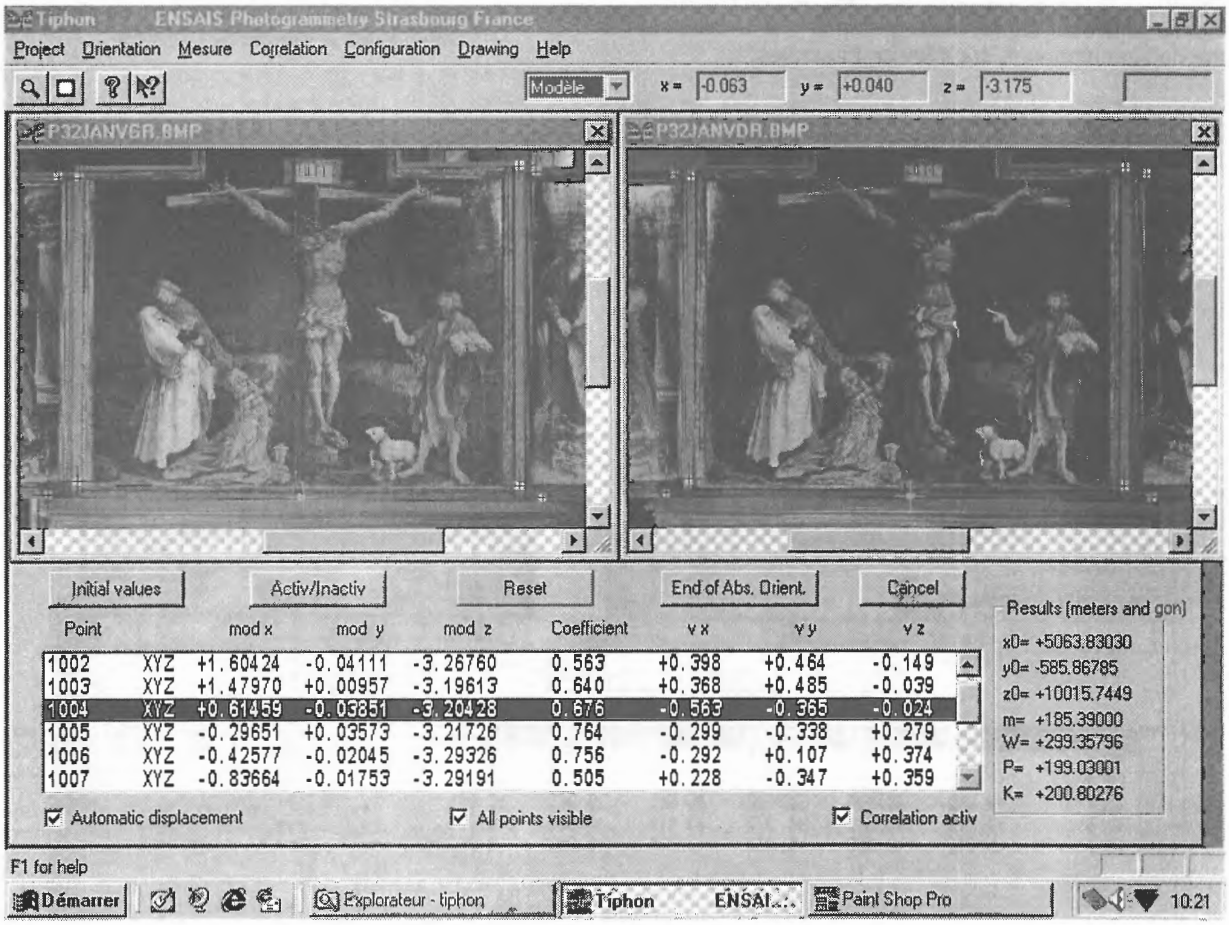

Figure 7 : the absolute orientation (here a spatial similarity transformation) with TIPHON

4. PHOTOGRAMMETRIC SURVEY WITH DIGITAL CAMERAS

In this paragraph we investigate the suitability of the FUJIX DS-300 digital camera for documentation in the architectural photogrammetric field with TIPHON. A variety of digital cameras are at present available on the market. The resolution range of the FUJIX DS-300 (1280x1000 pixels) is slightly higher than the most of the low resolution point and shoot digital cameras (Li, Faig, 1998). We know that digital amateur cameras don't fulfil the requirements of photogrammetry. The main problem is the mechanical unstability of the camera and the complicated variation of the camera's internal when frequently zoom in and out. But for mass documentation very high accuracy is not always required. The DS-300 camera has auto and manual control selections. For photogrammetric applications, the autofocus is disabled and the zoom lens is fixed at its shortest (or longest) focal length (equivalent to 35 or 105mm for 35mm film camera). Calibration at short intervals on a test field and self calibration during a project (Kraus, 1997) is of course advisable for such digital low cost cameras.

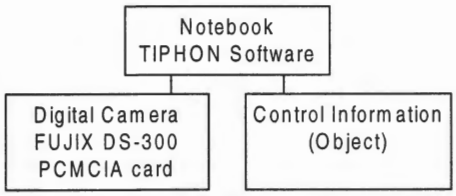

Figure 8 : digital fieldwork with TIPHON

The use of PCMCIA memory cards (5, 10, 15, 20 or 40 Mb) is very handy and efficient for digital fieldwork often requested by architects or archeologists.

Figure 9 : the FUJIX DS-300 Digital Camera

Resolution	1280x1000 pixels
Lens type Zoom lens autofocus (manual mode possible)	F=9/27mm equivalent to 35/105mm for 35mm film camera
F-stop	F 3.5, 5.6, 8 and 11
Shutter speed	1/4-1/1000 sec
Sensitivity	Equivalent to 100/400 ISO
Other features	Exposure compensation and white balance
Weight (with battery and PC Card)	Approx. 750 g
Storage media	PCMCIA PC card
File format	TIFF or JPEG
Price	Approx. 2000 $

Table 1 : main features of the FUJIX DS-300

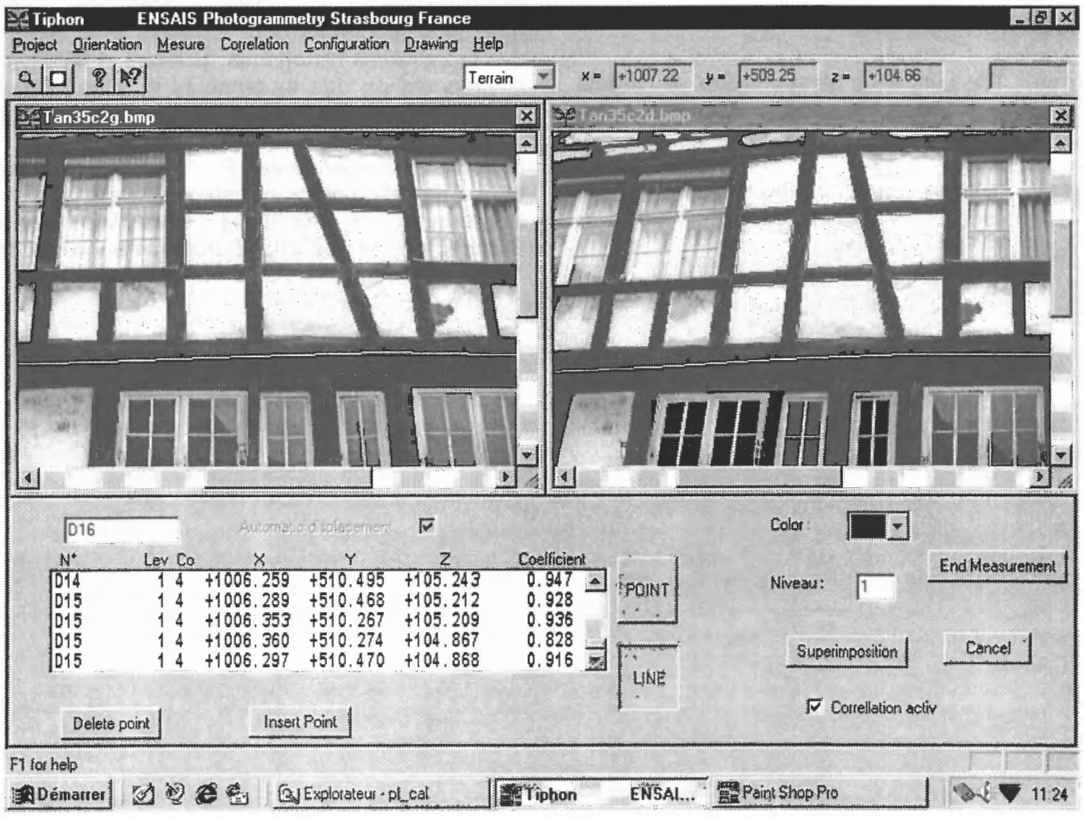

Figure 10 : digital stereoplotting (FUJIX DS-300 images) of a typical Alsacian House in the "Petite France" area at Strasbourg.

The figure 10 shows the digital stereoplotting menu of TIPHON and the possibility to superimpose the drawings on the left and right window. The user can also switch to a Microstation window during the plotting.

The presented example of half-timbered buildings at the "Petite France" at Strasbourg shows that the use of this kind of digital camera is possible with a distance camera to object of 15m in this example.

This application was possible thanks to the help of the FUJIFILM France Company and its interest in architectural photogrammetry.

CONCLUSION

The modules currently developed in TIPHON allow the standard processes of digital photogrammetric stereoplottings. The examples presented in this paper show that the TIPHON software is suitable for low cost documentation. The correlation routine available at each step of stereomodel compilation is the main feature of the software. The problem of the size of the digital images (and their resolution) will rapidly be solved by the increasing capabilities of PC-based computer.
The recent digital cameras with more than one million pixels will change the fieldwork methods, even if the mechanical unstability of the camera is a limit to accuracy. Documentation in the field or far away from the office becomes more and more possible at a low cost.

REFERENCES from Journals :

Höhle, J., 1997. The automatic Measurement of Targets. Photogrammetrie, Fernerkundung, Geoinformation 1/1997, pp. 13-21.

Li, X., Faig, W., 1998. A survey on Low-resolution Digital Cameras. Geomatics Info Magazine. January 1998.

REFERENCES from Books :

Albertz, J., Kreiling, W., 1989. Photogrammetric Guide. Wichmann, 292p.

Kraus, K., 1994 (with the contributions of P. Waldhäusl). Photogrammetrie, Band1, Grundlagen und standardverfahren. Dümmler Bonn.

Kraus, K. 1997 (with the contributions of J. Jansa, H. Kager). Photogrammetrie, Vol. 2, Advanced Methods and Applications. Dümmler Bonn.

Warner, W.S., Graham, R.W., Read R.E., 1996. Small format aerial photography. Whittles Publishing, American Society for Photogrammetry and Remote Sensing.

REFERENCES from Other Literature :

Benmlih, S., Grussenmeyer, P.,1995. Modern photogrammetric processes to the representation of complex architectures. The Medersa Bouinaniya of Fes. Proceedings of the GIS Euroconference, Karlsruhe 27.-29.9.1995.

Grussenmeyer, P., Abdallah, T., 1997. The cooperation in architectural photogrammetry between ENSAIS (France) and ECAE (Egypt). Practical experiences on historic monuments in Cairo. CIPA Symposium, Göteborg, October 1997. International Archives of Photogrammetry and Remote Sensing, Volume XXXII, Part 5C1B, pp. 215-221.

Grussenmeyer, P., 1996. Méthodes photogrammétriques modernes pour le relevé et la représentation des monuments historiques. Science et technologie pour la préservation des monuments et sites historiques, 2e séminaire régional, Damas, décembre 1996, 8 pp.

Morot, C., Grussenmeyer, P., 1996. Development of PC-based digital photogrammetric software at the ENSAIS Department of Surveying : the TIPHON software. Proceedings of the GIS Euroconference, Madrid, sept. 18-20, 1996, 6 p.