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COMPUTERS IN ARCHITECTURAL RECORDING: PHOTOGRAMMETRY METHOD

ABSTRACT

Architectural recording is the production of a full architectural representation of all the available architectural data of a building in a specific time. The record can be retrieved for preparation of conservation projects, archival backup and monitoring through time.

This paper is the Second among a series of papers directed towards exploring computers applications and the latest technologies in architectural recording applications. The main objective of these series of studies is to develop a comprehensive list of computer aided recording techniques suitable for architectural recording and documentation, aiming to improve the choice of technology thus improving the process of architectural recording and documentation.

The study starts by introducing a theoretical background on the basic concepts and definitions related to architectural documentation and recording, and then moves forward to identify the available technological alternatives and methods appropriate for architectural recording and documentation. Three methods are identified as suitable computer ready technologies, namely: Tacheometric methods, close range photogrammetry and close-range 3D laser scanners.

The paper then focuses on the photogrammetric method as an example of the available computer aided recording methods. A case in which this technique was used is then analysed, the study then concludes by determining the potentialities and limitations of the tacheometric method and identifies best practices for its application. Finally the study tracks the development of new techniques of computer aided photogrammetric analysis technologies.

KEYWORDS: Architectural recording, Architectural documentation, Computers, Tacheometric method, Practice, Egypt

Documentation:

The goal of documentation is to provide architects, engineers, and scholars with comprehensive information about buildings, sites, structures and objects of special significance. As mentioned in the guide lines for architectural and engineering documentation, made by the historic American building survey society:

> *"Documentation is used to provide the basis for enforcing preservation easement. In addition is often the last means of a preservation of a property, when a property is to be demolished, its documentation provides researchers access to valuable information that otherwise would be lost."* (HABS, 2003)

Documentation can be defined as the process which produces written, printed or other kind of material, furnished data and information for which knowledge might be derived, which, constitutes the knowledge base for a conservation process. (Laugerquist B., 1999)

The ideal documentation of an object would allow the user to gain the same complete information as the investigator who examined the original on site.

To sum up on this issue documentation was defined in the guidelines for the recording of heritage building in a statement of principles for recording and documentation historic building, which took place during the course of workshops conducted by the recording and documentation committee of ICOMOS 1988:

> *"Consists of compiling all available past and present records (written, graphic photographic, and the like) about an historic resource"* (Blumenson J., et-al, 1988)

Architectural documentation is the act of preparing plans, sections, and elevations for a building, showing spaces in relation to each other, levels, cracks, and damage to internal and external facades, In addition to recording all architectural and decorative details. (Abdul Reheem, G., et-al, 2002)

Architectural recording identifies three main steps: (Laugerquist, 1999)

- Recording as a backup of historic structures and buildings, in case if they should be damage or destroyed, or to be used through a valorisation process in a societal context,
- Recording in order to prepare conservation project documents,
- Recording as a monitoring device in order to detect changes which occur with the passage of time or because of external forces.

Technological Alternatives Suitable For Architectural Documentation

Recording tools cover many applications, tools and techniques of distance measurement vary from the simplest tools to the most sophisticated technologies that science and engineering have reached, with a wide range of applications. Here in this part, the study shall concentrate on one application only, which is the studying of measurement methods suitable for measuring the geometry of the architectural objects and buildings (not the topography), followed by the transcription of this data into usable architectural presentation. Even within this segment of technologies and techniques, it will be hard to list and describe all the technological alternatives that have been devised; the study shall concentrate on the most familiar techniques.

There are eight different technological alternatives for surveying methods that can be considered in acquiring measurements of an architectural object, and the following is a description of each:

Traditional measurement methods

- This system is the most usual method. Points are located in this system by direct distance measurement, this method is used very effectively if the site is accessible, not too large and easy to overlook, moreover development of handheld electronic distance-meter and software supporting automatic measurement control had made it much easier.

Tactile methods

- This system relies on the registration of the coordinates of the tip of a probe attached to the point required to be recorded. Several developments occurred to this system in the last few years in heritage object recording robot-like systems with automatic target detection. Different technical approaches have been developed in Coordinate Measuring Machines (CMM), in robot-like machines (e.g. Faro system) and in photogrammetric based systems (e.g. Aicon system).

Tacheometeric methods

- Tacheometry is the process of recording three dimensional polar coordinates of an object describing point's position through angle and distances. Intelligent Tacheometry is an automated controlled process with a computer, in addition to reflector less measuring totalstation. This enables integration with other methods of recording. Further uses and developments are shown like robot-totalstation and video total station.

Close range Photogrammetry

- This system is based on obtaining measurements from images, computer assisted analytical photogrammetry revolutionized the field widely. Digital images whether from CCD cameras or from scanned images have made it possible to produce a digital object model, which is a process more objective and easier than traditional photogrammetry.

Close-rang scanners

- Scanning is a method of obtaining points automatically or manually from the object with out contact thus producing a sort of digital model in a computer. There are different type of scanners most known are laser scanners and structure light scanners.

Global positioning system GPS:

- Can produce decimetre accuracy when used in different modes using carrier phase information and have proved very useful in heritage projects comprising large areas and for control points surveys for photogrammetric or satellite images processing.

Aerial photogrammetry:

- Is a well established method of surveying and standardizes to a large extents. Topographic mapping in intermediate scale is usually best accomplished by this method (if it is not prohibited).

Remote sensing:

- From satellites is a useful method in documentation, comprising large areas. (Imaging and processing techniques are becoming identical to digital photogrammetry).

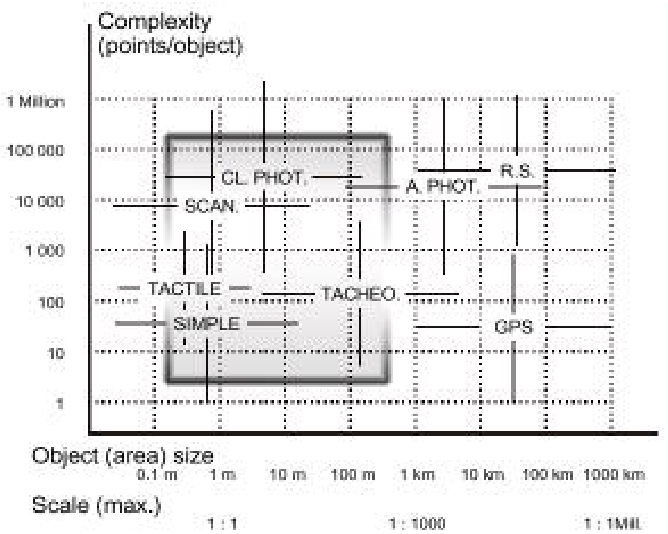

Figure 1: Recording methods considering object's size and object's complexity. Shaded area is the selected scope of the study (selected by the researcher) which represents the tools suitable for architectural recording applications. (Boebler, et-al.; 1999)

A common approach to recording the geometry of an object is through contact measurements, using traditional calibrated mechanical devices contacting and referencing positions of various points, like tape measure and folded ruler which are considered as simple measurement devices, or through tactile measurements which is a mechanical contact method based on XYZ recorder or an articulated arm used to touch a specific point on an object with great precision.

While, on the other hand there are non contact measurements techniques, which are divided into active and passive techniques; active techniques like laser scanners and tacheometric reflector-less EDM, or passive techniques like photogrammetric measurements, this issue will be discussed here in later.

A distinction must be made from the studying of the graph in figure 1, by observing the different types of recording methods related to the scale of the object and its complexity. For the purpose of the geometric recording of architectural objects for instance, the main disadvantage of mechanical approaches is that they are restricted to distances and volumes of few meters, and common problem is the danger of scratching the object when the tip of a probe touches the object therefore it will be excluded from the study, in addition, the wide range methods are unsuitable due to their wide range; ranging from one kilometre to thousands of kilometres, and thus, methods of large scale measurements will also be excluded from the study.

Therefore, four methods can be considered for architectural recording: traditional measurements, photogrammetry, tacheometry and 3D scanning. Discussing there characteristics it's obvious that each has strengths and weaknesses, and often they compete up to a certain amount.

Yet, the scope of this approach is limited to photogrammetric measurements suitable for the purpose of architectural recording, in order to understand this issue the study shall discuss the principle, procedures and potentiality of this method.

Photogrammetry measurements

Introduction

Photogrammetry is the technique of measuring objects (2D or 3D) from photographs; the most important feature is the fact, that the objects are measured without being touched (non contact measurements), therefore, the term," remote sensing" is used by some practitioners instead of "photogrammetry".

Photogrammetry has been defined by the American society for photogrammetry and remote sensing as: the art, science, and technology of obtaining reliable information about physical objects and environment through processing of recording, measuring, and interpreting photographic images.

Photographing Devices as the Basic Photogrammetric Tools

For the purpose of architectural photogrammetry the use of an expensive metric camera with known and constant parameters of interior orientation was for a long time, nowadays, more image acquisition systems based on digital sensors are introduced at reasonable prices on the market. (Grussenmeyer, et al., 2002)

The following section reviews the main photographic and digital image acquisition systems, which are used for the purpose of architectural photogrammetry.

Metric cameras and Stereo metric cameras

<u>Metric</u> cameras have a stable and precise known internal geometries and very low lens distortion, therefore, they are very expensive devices. The principle distances constant, which means, that the lens cannot be sharpened when taking photos. As a result, metric cameras are only usable within a limited range of distance towards the object. (Grussenmeyer, et al., 2002)

<u>Semi metric</u> cameras were then developed and are used in every day work of architectural photogrammetry, taking the advantage of reseau techniques in photographic cameras; a grid of calibrated reference marks projected onto the film at exposure, allows the mathematical compensation of film deformation, which may occur during the process of image acquisition, development and processing.

A single image cannot generate a 3D object; in this case the use of at least 2 images is necessary, often stereo cameras are then used. These cameras are composed of two calibrated metric cameras, which are mounted on a fixed basis in standard normal case; the line between the two projection centers is called stereo base, the both photographs have viewing directions, which are parallel to each other and in right angle to the base (is called the normal case). Therefore, the overlapping area of these two photographs (which is called the stereo pair) can be seen in 3D, simulating mans stereoscopic vision.

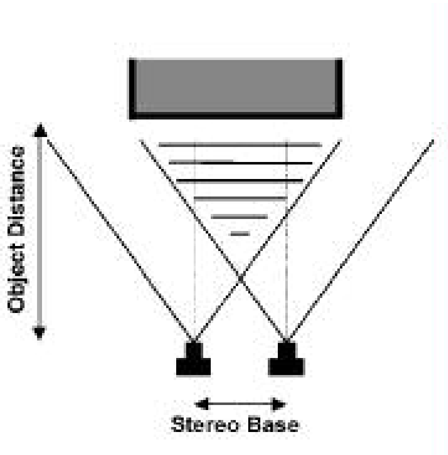

Figure 2 Stereo base of images; to generate a 3D object two stereo images are needed, stereo cameras are composed of two calibrated metric cameras, which are mounted on a fixed basis in standard normal case; (Grussenmeyer P., et al, 2002)

Figure 3 Zeiss SMK 120 set in normal position with the base and the lines of sight in the horizontal plane. (UNESCO, 1972)

Using stereo pairs of images 3D geometry can be reconstructed as long as the area of interest is shown on both images. (Grussenmeyer, P., et al, 2002

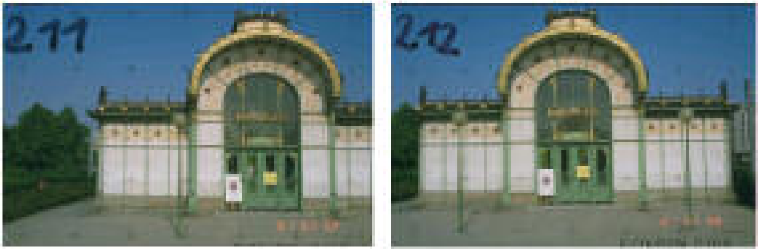

Figure 4 stereo pair images; 3D geometry can be reconstructed as long as the area of interest is seen in both images (from CIPA Otto Wagner Pavilion Karlsplatz, Vienna). (Grussenmeyer, et al., 2002)

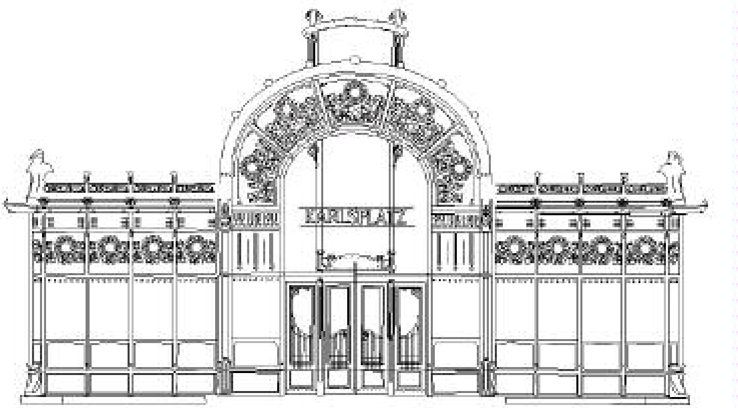

Figure 5 Resulted 2D façade from stereo pair images; derived from the above stereo pair of images using photogrammetric techniques. (Grussenmeyer P., et al., 2002)

Amateur's cameras

The photogrammetrists speaks of an amateur Camera, when, the internal geometry is unstable or unknown as in the case of any normal commercial camera on the market. These cameras are not dedicated for photogrammetric applications, yet in emergencies, where there are no other recordings available or in case of disasters, images produce then are priceless.

Digital cameras

The digital camera is one of the most remarkable instances of the technological shift made in the last twenty years. A digital image is arraystring of 1s and 0s that represent all the tiny colored pixels - that collectively make up the image.

The key difference between a digital camera and a film based camera is that the digital camera has no film; instead, it has a sensor that converts light into electronic images. The image sensor employed by most digital cameras is a Charge Coupled Device (CCD), some low-end cameras use Complementary Metal Oxide Semiconductor (CMOS) technology. The direct acquisition of digital images with a CCD sensor or a CMOS holds a number of advantages, which makes them interesting for photogrammetry.

Advantages of digital image acquisition:

- Direct data flow with the potential of online processing,
- High potential for automation,
- Good geometric characteristics,
- Independent of the film development process,
- Direct quality control of the acquired images,
- Low-cost system components.

Today more and more, high resolution digital cameras are used. Such cameras can be described as a combination of traditional small format Single Lens Reflex (SLR) camera with a resolution CCD sensor replacing the film. The main advantage of this system is the fast and easy image acquisition, moreover, the ability to transfer the images immediately to a computer and judge the quality of the acquired images.

Image scanners

For the use of architectural digital photogrammetry typically two different types of scanners are used, high resolution photogrammetric scanners and desktop publishing scanners.

PROCESSING DATA IN PHOTOGRAMMETRIC TECHNIQUES

Single image photogrammetry

Mapping from single image photograph is only useful for plane (2D) objects. Photographed objects show perspective deformations which have to be rectified. For rectification a broad range of techniques exists, from the simple methods to digital methods, however, there are some limitations.

Some common techniques are discussed in the following points.

Paper strip method

This is the cheapest method, since a single ruler, a piece of paper with a straight edge and a pencil is required. But of course it's outdated and no need to discuss this here.

Optical rectification

Optical rectification is done using photographic enlargers. Four control points are required, not three on one line, the control points are plotted at a certain scale and then the plotted control pints are rotated and displaced until two points match the corresponding object points from the projected image. After that, the table has to tilt by two directions, until the projected negative fits to all the four control points.

Figure 6 Optical rectifications; Optical rectification is done using photographic enlargers, developed by Carl Zeiss. (UNESCO, 1972)

Numerical rectification

As in the former methods, the object has to be plane and four control points are required. At the numerical rectification, the image co-ordinates of the desired object points are transformed into the desired co-ordinate system (which is 2D). The result is the co-ordinates of the projected points. Differential rectification in needed when the object in uneven, it has to be divided into smaller parts, which are plane. Each part can then be rectified with one of the techniques mentioned above.

Digital rectification

In digital rectification the acquired image is transformed pixel by pixel into the 3D world co-ordinate system. The result is an ortho-photo, a rectified photograph, which has a unique scale.

Commercial CAD/CAM software packages often include image handling tools and allow also image transformation and rectification (e.g. Photoshop and AutoCAD with the help of some plug-ins). But they seldom consider camera distortions, as opposed to photogrammetric software.

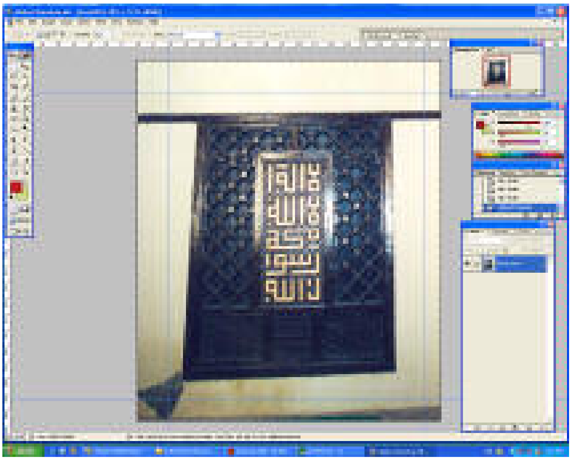

Figure 7 Digital rectifications; the rectification is made pixel by pixel, using Photoshop

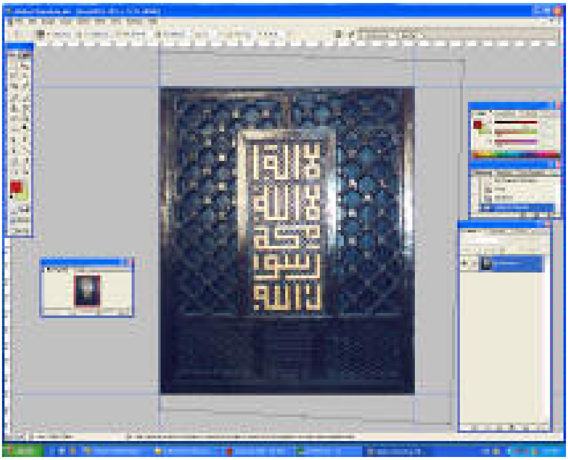

Figure 8 Rectified image; the image is rectified by a tool called perspective tool available in PhotoShop tools.

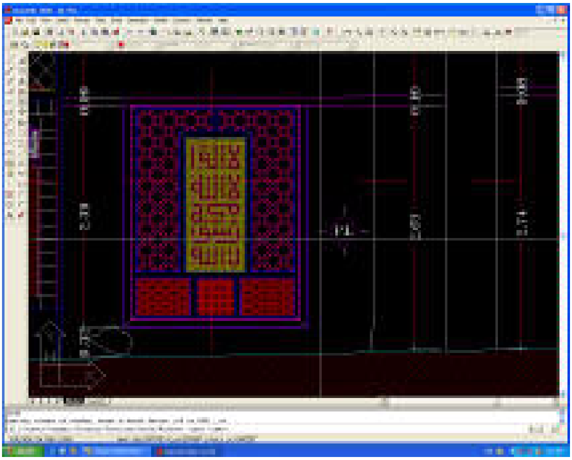

Figure 9 2D line drawings; the image after rectification is inserted in CAD software and is used as a background for manual drafting then the product is a 2D output.

These measurements can be control points or control distances. During the rectification process the reference measurements are assigned to the image. With the help of the assignment information the image can be transformed (rectified) arithmetically to a true to scale image plan. The plane where the reference measurements (control points, control-distances) are located is called rectification plane. All parts of the object that are situated directly in this plane are reproduced in true scale on the rectified image, elements that are not situated in this plane remains distorted.

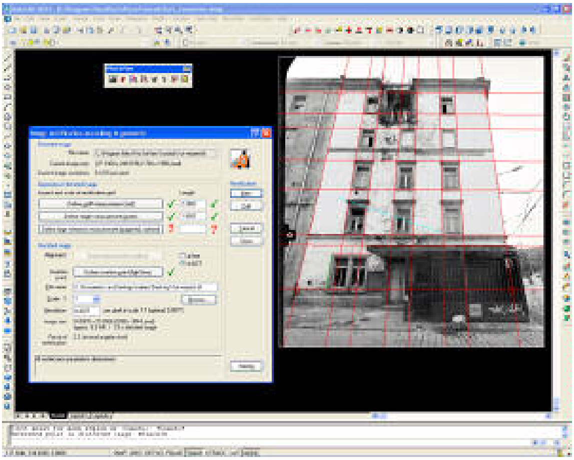

Figure 10 Digital rectifications; directly in CAD software using third party plugins; rectified image is created directly in AutoCAD and th Photoplan plugin.

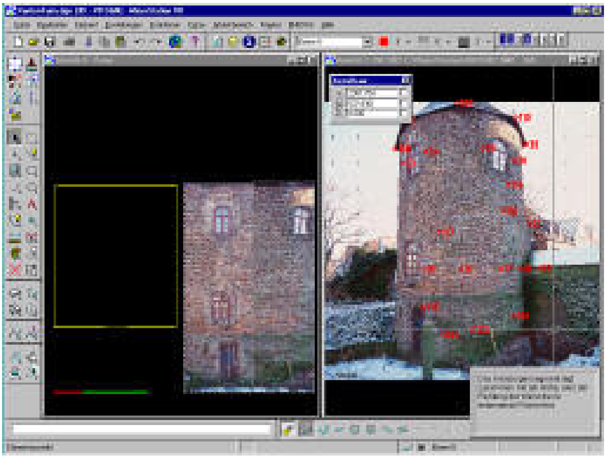

Figure 11 Digital photogrammetry; rectified portions of the elevation (on the left), monoscopic image with control points marked in red (on the right), using Phidias plugin with microstation CAD program.

Taking the advantages the 2D and 3D functions of CAD programs, photogrammetric plug-ins were developed (e.g. Photoplan software plug-in to AutoCAD), providing rectification functions and other perspective processing functions.

The base data is usually one or more photogrammetric images and/or amateur photographs of the object which are rectified at any planes defined by the user. Simple drawings (in vector-mode), images (in raster-mode) are processed as a result of the rectification. The Rolleimetric MSR is the most famous software package, provides scale representations of objects on the basis of rectified digital images.

Figure 12 Digital rectification; MSR software is the most famous professional software in digital rectification. (Grussenmeyer, et al, 2002)

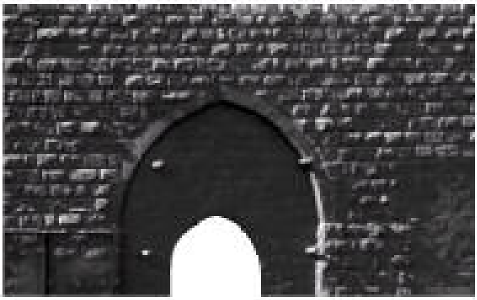

Figure 13 The rectified image produced by MSR software. (Grussenmeyer, et al, 2002)

Some packages include functions for the photogrammetric determination of planes according to the multi-image process from two or three photographs that capture an object range from different viewpoints. This will be discussed in the nest section.

Mono-scopic multi-image system

Mono-scopic multi-image systems, are designed to Handel two or more overlapping photographs, taken from different angles. The acquisition of linear objects can be directly evaluated due to superimposition in the current photogrammetric image. (Grussenmeyer, et al, 2002)

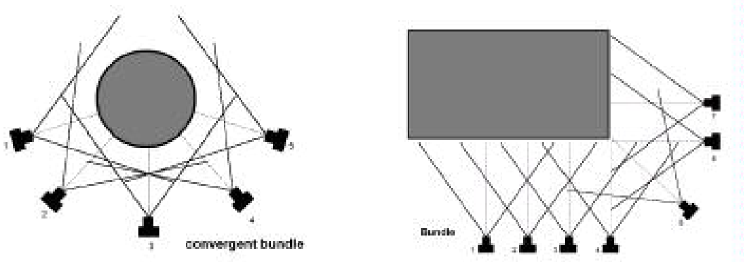

Figure 14 Monoscopic image bundel. (Grussenmeyer, et al, 2002)

The Canadian Photomodeler software package developed by Eos System is well known as a low cost 3D measurement tool for architectural and archaeological applications (http:// **www.photomodeler.com**). Photomodeler is windows based software that allows measurements and transforms photographs into 3D models.

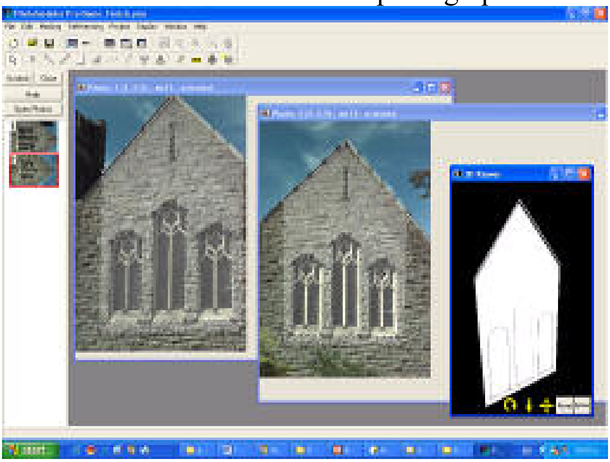

Figure 15 Digital photogrammetry softwares; an example of using multi monoscopic images in the generation of 3d record of a facad

The basic steps in a project performed with monoscopic digital photogrammetry: (Grussenmeyer, et al, 2002)

- Shoot two or more overlapping images from different angles of an object.
- Scan the image or use digital camera and then load them in photomodeler**.**
- Using the point and line tools, mark on the photos the points need to generate the model..
- Reference the points by indicating each point on different photograph representing the same location on the object.
- Process referenced data to produce a 3D model.
- Extract co-ordinates, distance and area.
- Export 3D model to CAD, rendering and animation software.

Figure 16 Reference points in the monoscopic digital photogrammetric softwares; the process is achieved by indicating each point on the two monoscopic images representing the same location on the object. (Grussenmeyer, et al, 2002)

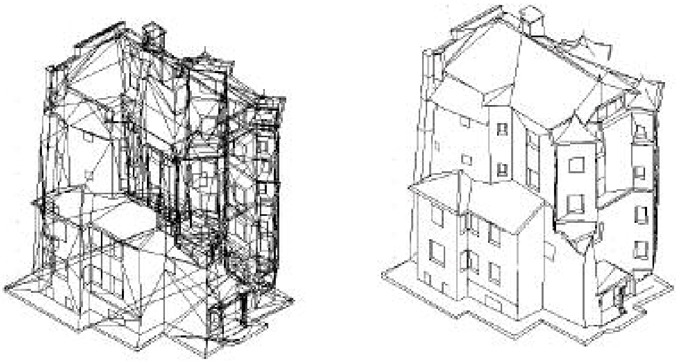

Figure 17 3D model reconstruction as produced after digital photogrammetry; wire frame generated from Photomodeler (on the left), surface render of the same model (on the right) (Grussenmeyer, et al, 2002)

Figure 18 3D rendered models; produced by digital photogrammetry using Photomodeler (Grussenmeyer, et al, 2002)

There is some other systems based on mono-scopic multi-image measurement, one of these is Photo 3D software. The software provide three sets of parallel reference presenting the estimated three axes XYZ of the real world and then the user adjust each set of parallel reference lines in the monoscopic images. The software then calculates 3D coordinates and provides the camera position.

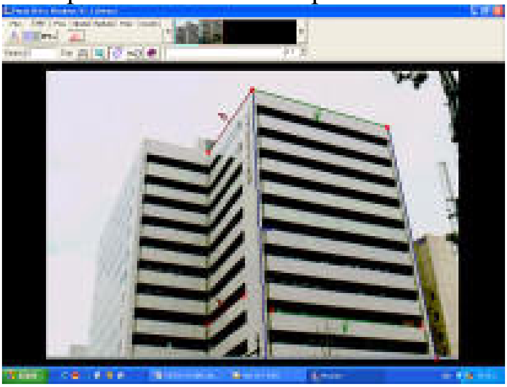

Figure 19 monoscopic digital photogrammetry software; using photo 3D refernce lines

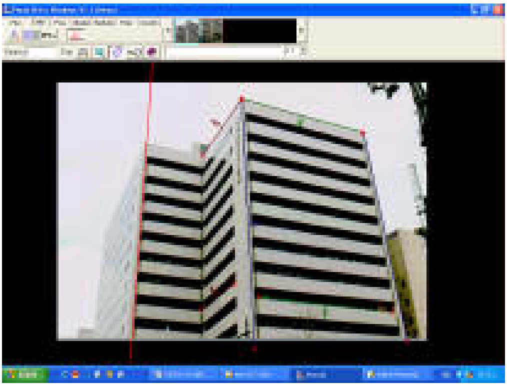

Figure 20 monoscopic digital photogrammetry provides auditing tools to check reference lines; photo3D cheching tool (checking prespective lines)

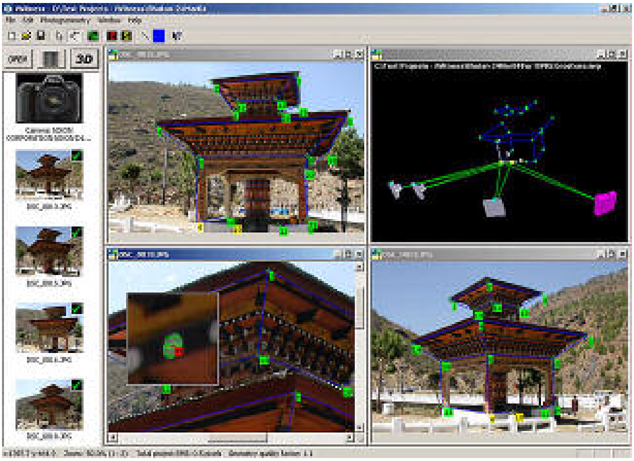

Figure 21 Another example of monoscopic phogrammetry software; i-Witness, shows numbers of monoscopic images and on the upper right the camera positions is computed.

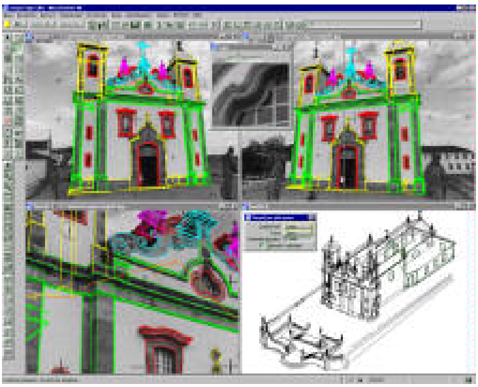

Figure 22 another example of monoscopic photogrammetry software; Phidias plugin used with microstation Cad software.

Stereo-scopic image system

The term stereo-photogrammetry implies that stereo pairs of images are the basic requirement here. They can be produced using stereo-metric cameras as discussed here after in this chapter, even if there is a single camera only available, two photographs can be made from different positions, taking into consideration to match the conditions of the "Normal Case". The overlapping part of each stereo pair can be viewed in 3D world and consequently mapped in 3D using one of the following techniques.

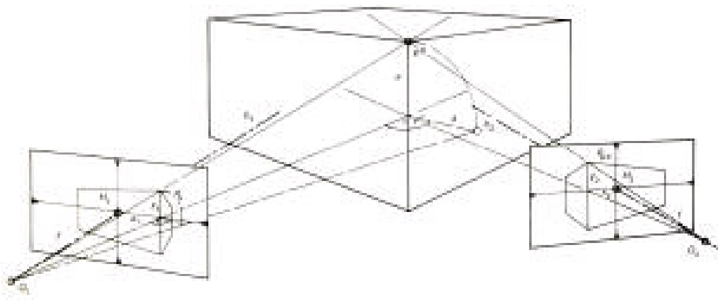

Figure 23 Stereo pairs generating the 3D model

Analogue system of stereo-pair photogrammetric systems

The analogue method was mainly used until the 70ies of the last century. Simply, the method tries to convert the recording procedure. Two projectors, which have the same geometric properties as the used camera, project the negatives of the stereo-pair. Their positions then have to be exactly rotated into the same relationship towards each other as at the moment of exposure. (Doneus, 1996)

After this step, the bundles of light rays projected from both photographs intersect with each other forming a model. At last, the scale of this model has to be related to its true dimensions and the rotations and shifts in relation to the mapping (world) coordinate system are to be determined. Therefore, at least three control points, which are not on one straight line, are required. The optical model is viewed by means of a stereoscope.

Figure 24 Analogue stereo pair photogrammetry; establishing a stereoscopic model in the bundesdenkmalamt (Vienna), the plotter is equipped with a ‘calculator-corrector; attached to the left of the operator’s hand for inclined axis shots, and in turn it drives the mechanism on the drawing board. (UNESCO, 1972)

Analytical system of stereo-pair photogrammetric systems

The first analytical plotters were introduced in 1957. From the 1970ies on, they became commonly available on the market. The idea is still the same as with analogue instruments. But here, a computer manages the relationship between image and real world coordinates.

The restitution of the stereo-pair is done within three steps: After restoration of the "inner orientation", where the computer may now also correct for the distortion of the film, both pictures are relatively oriented. After this step, the pictures will be looked at in 3D. Then, the absolute orientation is performed, where the 3D model is transferred to the real- world coordinate system. Therefore, at least three control points are required.

Digital system of stereo-pair photogrammetric systems

In digital photogrammetry, most of the measurements can be done automatically by correlation. The task is then to find the position of a geometric figure (called reference matrix) in a digital image. If the approximate position of the measured point is known in the image, then we can define a so-called search matrix.

Figure 25 Digital stereo pair; computers facilitate the process of stereoscopic vision.

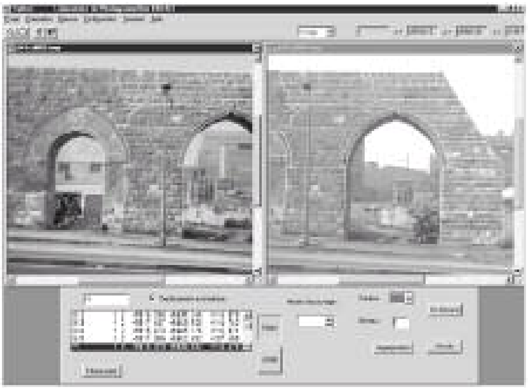

Figure 26 Digital stereo-plotting with image m Tiphon software showing the two stereoscopic images (Grussenmeyer, et al, 2002)

Emerging technologies

The last several years have seen significant progress towards automated view synthesis methods; like panorama tools. During the same time digital photography, together with the Internet, has combined to enable sharing of photographs on a massive scale. New systems consists of an image-based modelling that automatically computes the viewpoint of each photograph as well as a sparse 3D model of the scene and image to model correspondences.(Sanavely, et al 2006)

The system handles large collections of unorganized photographs taken by different cameras in widely different conditions; an automated process is the executed to detect camera positions and orientation. The camera pose enables placing the images into a common 3D coordinate system and allows the user to virtually explore the scene by moving in 3D space.

Figure 27 reconstructed 3D points and viewpoints fully automatically generated from a collection of images. (Sanavely, et al 2006)

There are three main categories of work related to this method: image-based modelling; image-based rendering; and image browsing, Image-based modelling (IBM) is the process of creating three dimensional models from a collection of input images, the field of image-based rendering (IBR) is devoted to the problem of synthesizing new views of a scene from a set of input photographs, and Image browsing, retrieval, and annotation software.

For large scale scenes, the advantage of Digital Elevation Maps (DEMs), used for example in Google Earth (earth.google.com) and with coverage of most of the United States available through the U.S. Geological Survey (**www.usgs.com**) To align point cloud reconstructions to DEMs, manually specify a few correspondences between the point cloud and the DEM, and estimate a 3D similarity transform to determine an initial alignment.

Figure 28 Screenshots from the explorer interface, showing location and orientation of various cameras. (Sanavely, et al 2006)

This reconstruction algorithm has several limitations that would be addressed in the future. The current implementation becomes also slow as the number of registered cameras grows, new technologies would like to speed up the process, for instance, by choosing a better order in which to register the photographs. A more efficient ordering might reconstruct the large-scale scene structure with a small number of views, and then register the remaining views using local optimization. Also, this robotic (automated) would be used to generated 3d point clouds from video sequence, where old demolished buildings can be retrieved from old videos.

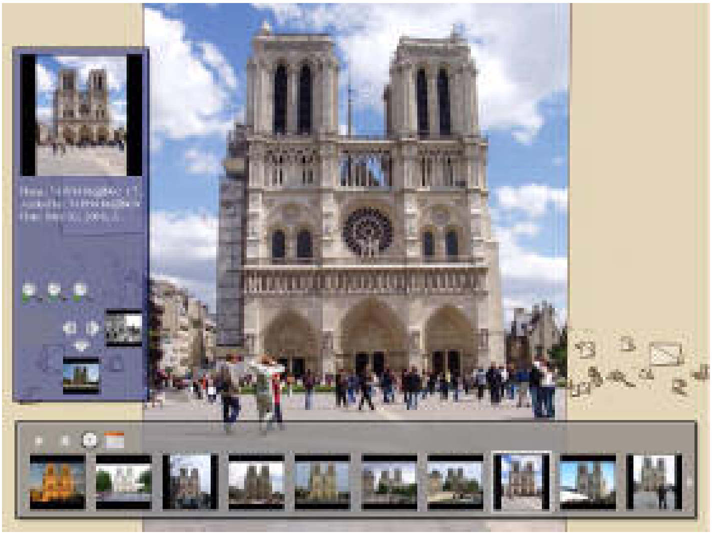

Figure 29 browsing interface of the new system (Sanavely, et al 2006)

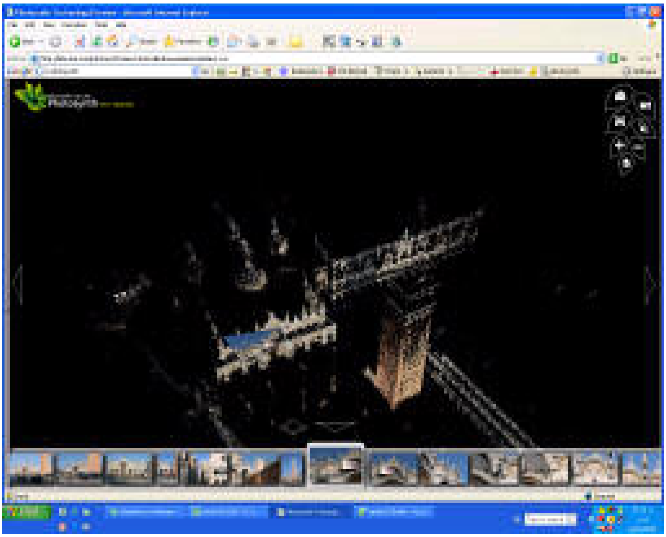

Figure 30 browsing interface of the new system showing clouds of points generated from the images. (Microsoft life website)

Advantages of Photogrammetry

- Photogrammetry documents objects without touching them. This is very often desirable with valuable architectural objects.
- In addition to models, photogrammetry provides also a photographic (very often stereoscopic) documentation of objects. In that way, a big number of important architectural objects can be documented in a short time and with little expenses. An analysis can be done, when desired.
- The quality of conventional recording very often depends on the qualification, interest or condition of the documenting specialists. The photograph is objective. Everything will be recorded automatically nothing can be forgotten.
- The accuracy of a photogrammetric analysis is in most cases better. Even, if cheap systems and "amateur cameras" were used, the errors will be rarely worse than those produces by conventional recording techniques.
- The features can be viewed and mapped in 3D.
- Experience shows, that if the features are recorded conventionally during documentation, different people have to draw. This will result in different and inhomogeneous drawings. If photogrammetry is consequently applied during the whole documentation, the documentation will be standardized.

Disadvantages of Photogrammetry

- The fact, that photogrammetry records an object remotely, can be also a disadvantage. If, for example cross-sections have to be documented, it is an advantage to be close to the material. Single layers, which sometimes differ only in compactness and in grain-size, can be distinguished only on site. This information would be lost.
- Small and important details of features are better documented on site with conventional methods.
- Only a few specialists can handle photogrammetric instruments and techniques. Operators, who are not familiar, are not able to correctly interpret the photographs.

Wakalat Qaytbay in Al Azhar (882 A.H. /1477 A.D.) List No. 75 (Case Study No. 2)

This documentation project was performed by The Egyptian Antiquities Project of the American Research Center (EAP, ARCE) on the Zawiya and Sabil of Sultan Farag Ibn Barquq in Cairo, Egypt. This monument is listed as Supreme Council of Antiquities Islamic and Coptic Antiquities monument No. 2032000-2001

Historic background

This Wakala was founded by Sultan al-Ashraf Abu al-Naser Qaytbay al-Garkassi after ten years of his assuming the rule of Egypt. Sources pointed that the Wakala was assigned for housing merchants and travelers, in addition to normal housing and commercial activities. (Islamic Capitals and Cities, 1992)

Figure 31 general view of Wakalat Qayetbay. (ECAE, 2005)

Architectural Description

From the remains of the *Wakala* it is observed that it is composed of three storey arranged around a spacious courtyard. The first floor used to contain water well and lavatories to serve workers in the shops and storehouses. Shops were located onto the street they are presently used for several commercial purposes.the two upper floors hold the housing apartments, the first floor consists of an *Iwan* and *Durqa'a*. The entrance is located in the north east façade, it consists of a recess with two setting benches on both sides, topped by two jambs and crowned by a trefoil arch. The exterior depends on the surface formation by using floral ornaments and geometrical decorations in the areas between the arches. (Islamic Capitals and Cities, 1992)

Documentation project

The objective of this module is the analysis of the documentation project; these analyses are performed in four parts. The first part considers the process of data acquisition, the second part reviews the processing of the gather data, and the third part discuses the object control which represent the tying of the processed information, the last part show the resulted product of the project

Data acquisition

The main technique used here in this project to gather the required geometric data, is the use of Digital mono-scopic multi-image photogrammetry to capture the current state of the building. The objects were photographed by digital cameras.

Figure 32 front facade of the Wakala. (ECAE, 2005)

Data processing

This part describes and documents the general procedure followed to create a correct and complete 3D geometric model of the *Wakalat* al-*Ghuri* in Cairo, Egypt. The aim is to record and present a virtual reality 3D model for the *Wakala* using multiple digital images. These images were processed using recently developed photogrammetric techniques, namely, Phidias software package developed as a plug-in to the well known Micro station Cad software package. This technique not only allows fast and accurate representation of the undocumented architectural heritage, but it can also achieve this goal in an inexpensive manner.

Figure 33 rectified image of the trifle formed arch in the top of the main entrance. (ECAE, 2005)

Figure 34 rectified elevation; using rectified elevation as a mapping material for the production of the textured model. (ECAE, 2005)

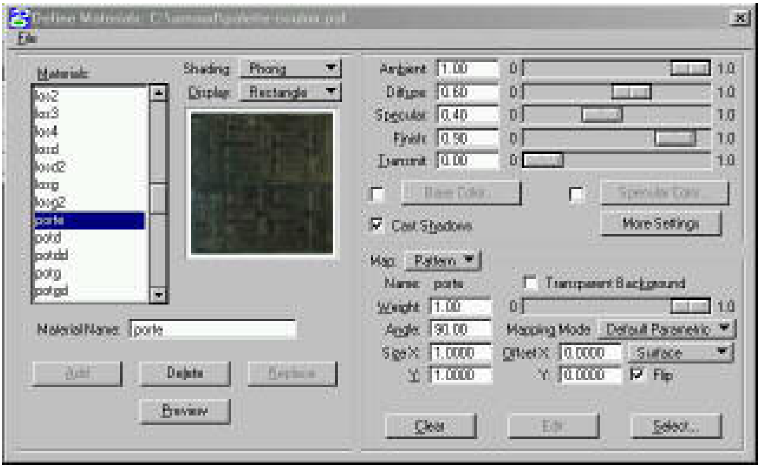

Figure 35 Appling textures and maps obtained from the images; the defining material dialogue box for the generation of the textured 3d reconstruction model. (ECAE, 2005)

Object control

The process here in tying the captured data is by using reference points indicated by the user on there captured images, processing reference data is automated, the relative co-ordinates, distances and areas is extracting from the relative 3d model. Total station or manual means of registration is then needed to tying up the generated model to the real world.

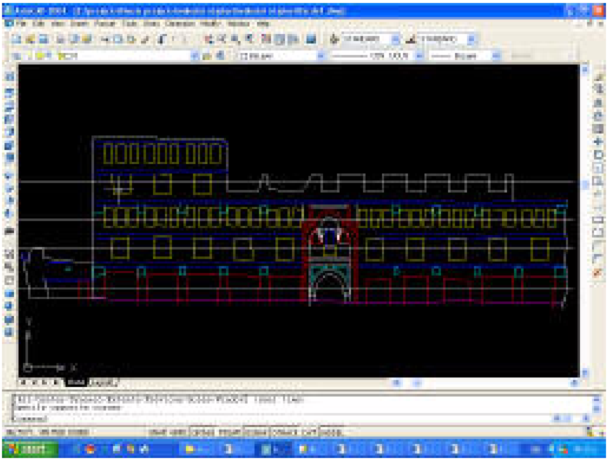

Figure 36 captured lines of the main elevation; points and lines representing the main faced of the wakala captured with a total station to tie up the gathered photogrammetric images

Record production

Building planes had to be setup very carefully and with the help of the captured points with the total station. Obtaining any model within a reasonable time required giving up some details, which may be fulfilled later to complete the project.

Figure 37 3D reconstruction isometric view of the building; textures derived from the photos are applied to the generated 3d model and referenced with the total station to produce a full textured 3D reconstruction. (ECAE, 2005)

Figure 38 3D reconstruction isometric view of the building; Obtaining a model within a reasonable time, then details can be fulfilled later to complete the project (ECAE, 2005)

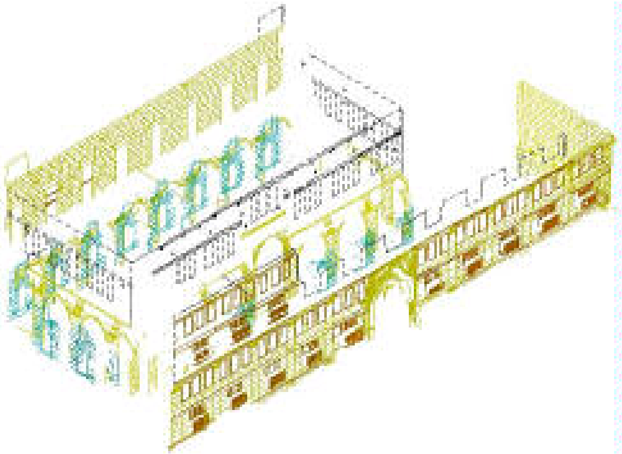

Figure 39 Isometric view of the generated wire frame line drawing. (ECAE, 2005)

Potentialities

First of all is the short site time; accurate model can be obtained in a short amount of time, in addition to the possibility of completing other details when needed. More over, non contact measurements provide safe means of capturing data. This process is also considered as a direct path to 3d visualization.

Limitations

Administration of photos and creation of the photogrammetric project requires care and good management. The process consumes more office time (offsite time) than that of the total station. Good total station points are essential for error correction, and the process of tying up the model to the real world since the photogrammetric software computes relative measurements and co-ordinates.

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