USE OF AMATEUR CAMERAS IN ARCHITECTURAL PHOTOGRAMMETRY

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Abstract

Photogrammetry has become more widely used in the application of architectural measurement particularly in the field of conservation and restoration. For more than a century, photogrammetry has been done by specialists who took pictures with special metric cameras, which are specially designed for photogrammetric purpose. Documentation for huge number of architectural structures with these cameras prove to be very costly. The use of the many amateur cameras in the world seems to be the only realistic possibility for a more or less complete and permanently updated documentation of the enormous quantity of architectural and other cultural objects within a reasonably short time. The present work highlights on the use of amateur photographs to use for photogrammetric purpose to produce 3D photorealistic models which can be used in documentation for further work.

1. INTRODUCTION

Documentation of historic monuments is very important in the conservation aspect or atleast to save its memory. Using photogrammetric techniques for architectural documentation is largely used and is presented as a source of metric information. Technical guidance in how to take photographs can be found in almost all photogrammetry text books. Various authors have proposed methods for photographic recording approach to respond to the increasing pressure for the documentation of cultural property. But the methods for using amateur cameras in photogrammetric documentation are very rare. Depending on the restrictions due to the photogrammetric reconstruction process in former times, only metric cameras with known and constant parameters of interior orientation could be used. Their images had to fulfill special cases for the image acquisition. Due to the ongoing destroying of the world cultural heritage it will be necessary also in the future to reconstruct objects taken with amateur cameras (Waldhäusl and Brunner, 1988).

2. AMATEUR CAMERAS IN ARCHITECTURAL PHOTOGRAMMETRY

For more than a century, Photogrammetry is done with photographs taken with metric cameras only. As these cameras prove to be costly and also to save time, now the photogrammetrists are switching to use amateur cameras to document large number of architectural monuments. Photographs can be either acquired by an analogue film camera and can be used for digital analysis after scanning these photographs or use directly the digital camera which bypasses scanning, in digital photogrammetric environment. Nowadays digital cameras are becoming more available with larger sensor size, higher resolution and lower costs. To use photographs for reconstructing buildings, the geometry (focal length and principal point) and the orientation of the camera have to be recovered. Besides focal length, the position of the principle point and distortion parameters a factor has to be considered, that describes different scales in the image

coordinates. It is possible to use amateur cameras for photography and derive all geometric properties of the recorded objects from these images (Kurt Novak, 1990). From a pair of photographs it is possible to construct a sub-centimeter model that can be vectorized to produce DXF output for use in all CAD or GIS applications. Historic buildings such as churches or castles with complex carvings or textures can be easily imaged in digital photogrammetry.

3. RULES TO ACQUIRE DATA WITH AMATEUR CAMERAS

In Architectural Documentation using close range photogrammetry, the art and method of taking photographs have been given by "3x3" rules (Waldhäusl & Ogleby., 1994). These rules which are to be observed for photography with amateur cameras in close range photogrammetry for best results. These rules are called so because they are structured in three items, with three sub-items each. There are:

A) 3 Geometric
B) 3 Photographic
C) 3 Organizational

3 geometrical rules

I. Preparation of control information:
   - Well defined points having large distances between them should be chosen.
   - Plumb lines should be defined which can be made by plumbing down e.g. a roof corner and by targeting of the foot.
   - It should be done on several sides of the building for control.
   - At least one distance (Horizontal) and one plumb line (Vertical) should be known as minimum metric information.

II. Multiple photographic coverage all-around objects:
   - If possible shots from half the object's height should be taken.
   - Parts of the neighbourhood should also be included.
   - Add diagonal shots combining two sides of the object.
   - Add traversing shots combining the neighbouring photographs.
   - Multiple coverages of details should be present.
   - Add orthogonal full facade shots for overview and rectification.
   - "Ring" of pictures all around the picture with overlapping each other more than 50% should be there.

III. Stereo partners for stereo-restitution should be taken:
   - Stereo partners are taken as in Normal case (base-distance-ratio 1:4 to 1: 15), or in convergent case (base-distance-ratio 1:10 to 1: 15).
   - Divergent case should be avoided.
   - Close-up stereo pairs for valuable details should be added and additional control distances should be measured for them.
   - In case of doubt, more shots should be added and measured "by hand" whatever remains invisible.

3 photographic rules

I. The inner geometry of the camera has to be kept constant:
- There should be no zooming, zoom optics should be avoided at all.
- No changes in distances between camera positions and camera-object. One distance for "ring"-photography should be adopted.
- One distance for close-ups should be adhered.
- Image format frame of camera must be sharply visible on the images with good contrast.
- The true documents are the original negatives. They should be treated and kept carefully.

II. Homogenous illumination should be selected:
- Best time of the day when there is bright light should be selected for taking photographs so that photographs are obtained with best contrast.
- Tripod should be used and chaining of tripod legs should be done for sharp images.
- Any film may be used. Black-and-white is sufficient, colour provides advantages for interpretation.

III. Most stable and largest format camera available should be selected:
- Wide angle is better than narrow angle for all-around photography.
- Medium format is better than small format.
- Calibrated (or metric) cameras are better than non-metric.

3 organizational rules

I. Proper sketches should be used:
- Sketches of Ground plan, Elevation of each side (1:100-1:500) are imperative.
- Object, owner and address should be noted down.
- North direction should be marked.
- Photo standpoints (with film and negative number) and photo directions should be marked.
- Single photo coverage and stereo coverage should also be written down.
- Control distances and plumb-lines should be shown on sketches.

II. Following proper protocols should be written down:
- Object, owner, address.
- Date.
- Camera, optics, and distance settings.
- Calibration report, if available.
- Description of place, object, history.
- Bibliography.
- Specials, artists, architects, permissions, obligations, etc.

III. Don’t forget the final check:
- Everything should be written down immediately.

- Completeness and correctness of work should be checked before leaving the site.
- Reports should be concluded while remembering all details.
- Results should be checked together with an authority for monuments and sites.

4. SOFTWARE AVAILABLE FOR ARCHITECTURAL PHOTOGRAMMETRY

Computer-assisted design (CAD) software has the potential to revolutionize data recording and presentation in architectural photogrammetry. Instead of making static, scaled, 2D drawings, one can record the geometry of their subjects and display the results as 3D models , on screen or on paper. The main aim of 3D visualization used in close range photogrammetry is photorealistic reconstruction of a real object. Currently the most common standards of presenting analytical and digital photogrammetric processing results are CAD systems, e.g. AutoCAD, IntelliCAD, and MicroStation. These programs enable to save vector data in 3D format files: DXF, DWG and DGN, which allow creating additional geometric and graphic constructions using a raster processing module.

i) TIPHON

TIPHON allows photogrammetry with different kinds of cameras. The inner orientation function of the software package can manage the different type of images and takes into account the distortion of the calibrated objectives. The measurements on the images are manual or semi-automatic by correlation. The automatic measurement by correlation modifies the way of stereoplotting in architectural photogrammetry can be produced just by measuring accurately on only one image of the stereopair (Grussenmeyer, P., Koehl, M., 1998).

ii) DIGICAD 3D (http://www.interstudio.net/DigicadE.html)

DigiCad 3D is an excellent tool for dealing with images, drawings, photographs of building facades and maps. It operates either directly on raster images or by digitization. It is used in photogrammetry, cartography and, increasingly in recent years, in architectural photogrammetry, for which it offers powerful, easy-to-use and exclusive instruments.

iii) PHIDIAS (http://www.phocad.de/Produkte/PHIDIAS/English/english.html)

PHIDIAS is a powerful digital photogrammetric system which is used for any kind of image measurement. PHIDIAS is integrated into MicroStation and well suited for 3-dimensional documentation of complex buildings and facilities. PHIDIAS is the latest development in the filed of digital photogrammetric workstations. The data generated by PHIDIAS will be directly stored in MicroStation design files and processed there.

iv) iWITNESS (http://www.iwitnessphoto.com)

iWitness is a PC-based image measurement and data processing system for multi-image, close-range photogrammetric measurement. iWitness has the familiar features of 2D image mensuration for an essentially unlimited number of images, points and cameras. Moreover, it incorporates user interfaces and interaction that are designed to support maximum ease of use.

v) PHOTOMODELER (http://www.photomodeler.com)

PhotoModeler is a Windows-based digital photogrammetry program that lets you create accurate 3D models of existing objects by digitizing common points in sets of photographs of the objects taken from different vantage points. One can use digital photographs (the most convenient), scanned conventional photographs, and captured video images as source material. The calibration process is completely automatic. Unknown camera can also be used to generate reasonably accurate models from individual photographs of unknown origin.

vi) ELCOVISION (http://www.elcovision.com)

Elcovision is the universal software for the 3D measurement from each kind of images. This very user-friendly software enables anybody to measure very efficiently and simple 3D data from images. It accepts virtually all image sources such as pictures of digital cameras, pictures of metric cameras, scanned photos, Kodak PhotoCD and ImageCD, grabbed images of video cameras and so on. Starting from the low-cost basic version, up to the professional solution with up to 1.000 photos in the bundle adjustment process with on the fly camera calibration and the option to use normal amateur photos in the photo block, Elcovision offers the right tool for each measurement task.

5. CASE STUDIES

5.1 Documentation of Roman Temple (Hanke, K., 2001.)

The Roman temple was recorded using simple amateur Cameras and the "3x3 rules". The temple was photographed from different positions, so that every point, that would contribute to the 3D-model later on (corner, column, steps, roof...), was recorded on at least 3 photographs. Additionally, to be able to scale the model later on, 8 targets were attached to the temple walls and the distances between them were measured. During the documentation, a sketch was drawn including every photo position, the measurements and other important information. The accuracy depended on several factors as e.g. the quality of the used camera, the angle between the viewing directions of the photographs, the number of photographs on which each point is marked, the scanning resolution etc. In this case, the accuracy averaged between 5 and 15 cm. After the model of the temple was at a satisfying level of detail, the data were exported and used in other applications, as CAD-systems, programs for digital image enhancement and 3D-rendering and animation software.

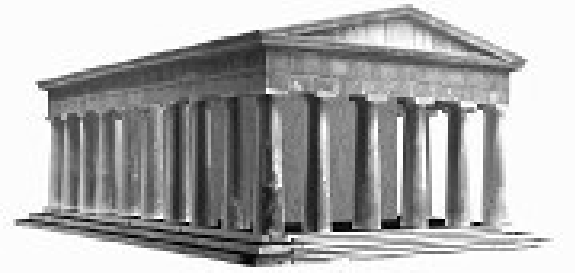

Fig. 1: Rendered view of the model

5.2 Creation of 3D model of Taj Mahal (Paul E Debevec., et al, 1998)

An image of Taj Mahal which is found on internet (Fig. 2a) was used to create 3D model. Edges were identified and contours are marked on the photograph. The edges of the recovered model, overlaid on the original photograph (Fig. 2b). The recovered model, flat-shaded, with pointed Islamic arches is done (Fig. 2c). The system made it possible to leverage the symmetries in the Taj Mahal and to construct this complex model using digital photogrammetry.

(a) (b) (c)

Fig. 2: 3D Model generation of Taj Mahal

6. CONCLUSIONS

It has been shown that the restitution of small format amateur cameras brings results with an accuracy which is good enough for most architectural needs. These amateur cameras can be used for the upcoming tasks of creating fundamental collection of architectural monuments using 3X3 rules for photogrammetry. The purpose of this paper is to build the bridge between photogrammetry and institutes, societies as well as people who take pictures not only for holiday memories but also for practical or scientific purposes.

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