

SIMPLE TOOLS FOR ARCHITECTURAL PHOTOGRAMMETRY

V. Tsioukas

Department of Architectural Engineering, The Democritus University of Thrace
vtsiouka@arch.duth.gr

KEY WORDS: Photogrammetry, Surveying, Architecture, CAD, Cultural Heritage

ABSTRACT:

In this paper a CAD application embedding photogrammetric procedures is described. Oleg Kolbaskin has originally created the CAD application and the photogrammetric procedures were programmed in the Department of Architectural Engineering of our Institute. The software can be used from both novice and experienced users in order to provide rectified images for cultural heritage documentation usage in the best quality using appropriate calibration and monoscopic image processing algorithms. Since it is based on a CAD environment further restitution and drafting can be followed in order to provide the 2D top view plans and facades' plans of sites and buildings.

The original images are calibrated and corrected using an advanced image processing software procedure that provides the final images to be rectified. The rectified images may be then produced using either the classical digital rectification algorithms of the central projection solution or the perspective geometry solution (geometry correction based on the determination of vanishing points).

1. INTRODUCTION

One of the main tasks of the Architects' profession is in the field of Architectural Conservation and Restoration of Buildings and important Cultural Heritage Monuments (archaeological sites, excavation sites, traditional settlements, urban complexes of high historic value, etc).

The expertise, an Architectural Engineer should have in order to have the ability to accomplish the hard task of a restoration, should include special knowledge on modern recording techniques since they will help him to prepare a proper documentation. The results of the documentation project will lead to the final restoration study of the building. The appropriate techno-economical study will give the best profit result of the restoration.

A basic tool for the creation of the digital recording files of top-views, section and facade plans for the documentation of a building is a CAD software application. For the recording of flat vertical facades, the procedure of digital photogrammetric rectification has been applied with great success in several cases in the past (Dallas, 1996).

AutoCAD by AutoDesk, the well-known digital design and drafting application, is the first software tool found in an Architect's office. It has been used with great success for the creation of 2D designs and 3D models of buildings. Although, the basic version is embedding some raster processing algorithms it does not include photogrammetric processing modules. For that reason, most of the owners of an AutoCAD software license are using an add-on module to create rectified images and mosaics of buildings' facades (Colorview GIS ImageRectifier by Peak Geo-Design, Inc.; ELCOVISION by PMS Photo-Mess-Systeme AG; PhoToPlan by kubit GmbH; SUPER/IMPOSITION by Datem). In other cases, the users prefer to use standalone raster processing applications to create the rectified images, which are later inserted in the AutoCAD environment to produce the final restitution designs.

Similar applications exist also as add-on modules for the Bentley's Microstation CAD application (Intergraph's IRAS/C

and Bentley's Descartes). The Microstation application has been used from several recorders in the past.

In the past, some researchers have developed their own non-commercial applications in order to rectify digital images in architectural recording projects. Their aim was mainly to create the appropriate tools equipped with all the necessary features to accomplish their heavy research tasks and not to merchandize their applications.

2. PHOTOGRAMMETRIC RECTIFICATION

2.1 Based on Control Point Measurements

The most of the applications that create rectified images coming from either conventional or metric cameras are using the projective transformation equations to define the relation between the film or digital sensor plane and the recording plane of a building's facade. In this case, the building's facade is considered flat and low relief is assumed to produce negligible deformation on the final rectified image. The observation-measurements of at least four control points (predefined and topographically measured) on the image will lead to a solution of the unknown parameters that is connecting every point of the facade onto its digital image. The rectified image is finally generated through the resampling process.

The advantages of the method are:

- Quality control. By using more than the four minimum control points and through the statistical analysis it is possible to estimate the mean error and standard deviation of the produced rectified image. Adjustment is providing the optimal solution of the rectified image.
- The connection of every point on the rectified image to the local coordinate system is feasible. The local coordinate system is implemented with the use of a common Total Station used to define the control points location on the building's facades.
- It is a fast and easy process.

- It is leading to a complete digitisation, if the rectified image is used properly in a CAD environment.

2.2 Based on vanishing point geometry

In the case where it is not possible to measure points on the building's facade (due to the inability to access the building, or if the image has been created from an old photograph scanning)

3. OUR APPROACH

In the teaching process of courses concerning digitisation, recording and restitution of buildings' facades using surveying techniques and Photogrammetry, common commercial CAD applications have been used in our Department. The computers in the laboratories of our Department are equipped with the appropriate commercial applications to produce rectified images and are able to provide digital 2D designs of buildings'

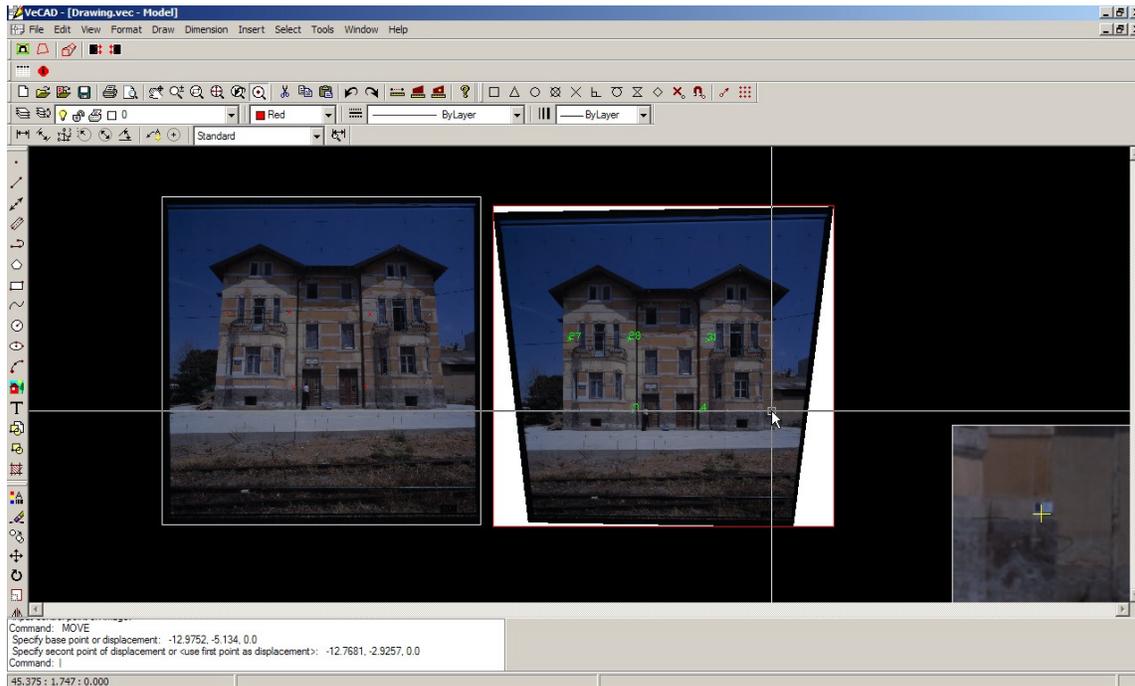


Figure 1. The rectified image was produced using control points measurements. In the lower right corner of the drawing space a magnifier window is displaying, in zoom, the region around the cursor.

the definition of the vanishing points on the image, through the collection of parallel horizontal or vertical lines, can determine the position of the camera in relation to the building's facade locus (Karras, 1992). A similar product as the rectified image is generated. However, it lacks the quality control provided from the typical digital rectification process since no redundant control point measurements exist. No adjustment is applicable and only a couple of distance measurements can be used to calculate the final rectified product. The measurements that are used are horizontal and vertical distances that provide the correct scale of the rectified image (Karras, 1992; Fangi, 2001).

However, the advantages of the method are the same as in the previous case of a rectified image using control point measurements. Additionally:

- No complicated measuring devices and topographic networks are necessary
- They provide a rectified image product in a very short time. However, the users of this photogrammetric procedure might not or do not want to have any knowledge of photogrammetric theory

facades. However, the software licenses in the laboratories does not cover the elaboration of recording projects away from the university facilities. The students have the need to execute the photogrammetric and digitisation applications on their personal computers at home. This need has lead the author to develop a software application that will have the ability to provide digital rectified images using both the previously mentioned techniques and is free of charge to be used by anyone (student or not) for non-commercial applications and projects (educational and research purposes).

The software has been based on the source code of VeCAD, provided by Oleg Kolbaskin and is comprising of a full CAD application. The contribution of the author was to embed all the photogrammetric processes to produce the rectification of a central projection image, using control point measurements (figure 1) or vanishing point geometry correction (figure 2). Many of the features of the CAD environment are very similar to the ones of the common commercial applications.

Another application has been developed by the author to contribute in the best possible way to the creation of the most appropriate photogrammetric products. Since, the images that are processed are mainly coming from typical commercial digital cameras (i.e. student cameras) the low quality of their lenses are generating great radial distortion errors (figure 3a). The image calibration application, that has been developed, is

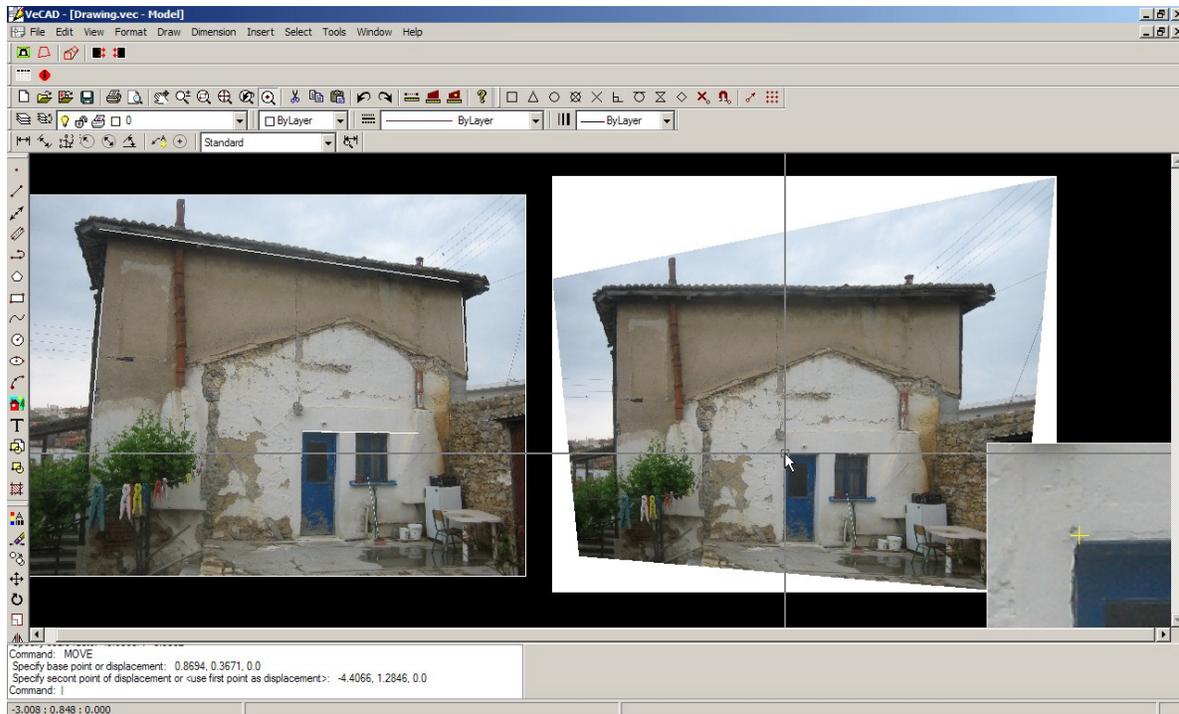


Figure 2. Original (left) and rectified (right) images processed in the CAD Environment. The rectified image was produced using vanishing points geometry.

used to calculate the radial distortion parameters according to the Beyer model (Beyer, 1992). Prior to the use of the camera the user is taking a snapshot of an A4 printed targets page (of circular shape) that are automatically identified and defined accurately on the image using a best fitting ellipse algorithm. Using a resampling and filtering image processing procedure, every image generated through the specific camera is then corrected (figure 3b) (Sechidis, 1999).

4. FUTURE RESEARCH

Since the first step has been made to provide a photogrammetric tool mainly for Architects and Surveyors for the recording of building facades, we are planning to add more valuable features to this freeware software application.

Some of the future research targets are:

- The database management of all the available data within an architectural recording project including original and rectified images, surveying measurements sketches and site maps, etc.
- The embedding of the basic surveying problems solution
- The ability to create image mosaics coming from overlapping rectified images covering in tiles the whole building's facade.

Although, the educational (and some of the research) purposes are totally fulfilled through the current characteristics of the software, it is very important to include all the abovementioned features that will improve its functionality and usefulness among the scientific society of Architects, Surveyors and all the people that are dealing with the Cultural Heritage recording.

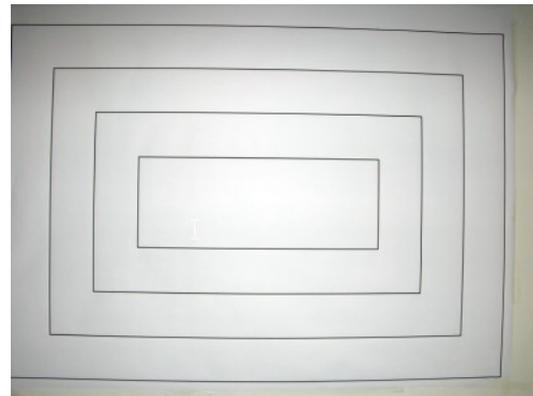


Figure 3a. Radial distorted test image.

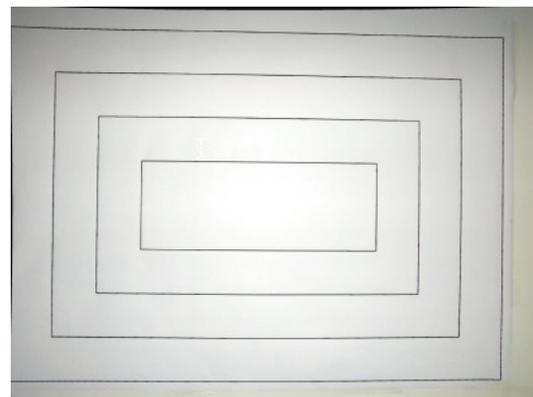


Figure 3b. The corrected test image.

5. CONCLUSIONS

The author has developed a software module and a software application to support the teaching and research activities in the Department of Architectural Engineering of the Democritus University of Thrace. The application is able to provide rectified images using typical photogrammetric processes in a CAD environment featuring:

- No cost (but only for non-commercial applications)
- Low hardware demands
- Ease of use for an experienced CAD user

The main aim of this research activity was the spreading of photogrammetric image processing practice especially for the recording purposes of buildings and sites, by an Architect or a Surveying Engineer.

6. REFERENCES

- Beyer, H., 1992, *Ph.D. Thesis: "Geometric and Radiometric Analysis of a CCD-Camera Based Photogrammetric Close-Range System"*
- Dallas, R.W.A., 1996, *Architectural and archaeological photogrammetry. In Close Range Photogrammetry and Machine Vision*, K. B. Atkinson (ed.), Wittles Publishing, Caithness, pp. 283-302
- Fangi, G., Gagliardini, G., Malinverni, E.,S., 2001, *Photointerpretation and Small Scale Stereoplotting with Digitally Rectified Photographs With Geometrical Constraints*, Cipa 2001 XVIII International Symposium, Potsdam, Germany
- Nickerson, S., Chapiro, A., 2005, *ASRix : A Simple Digital Image Rectifier*, CIPA 2005 XX International Symposium, Torino, Italy
- Karras, K., Petsa, E., 1992, *The use of perspective in uncalibrated images for the documentation of the facades of historic buildings without control*. Terrestrial Photogrammetry and Spatial Information Systems for the Documentation of Cultural Heritage. Ziti Editions, Thessaloniki, Greece, pp. 199-212 (in Greek).
- Sechidis, L., Georgiadis, C., Patias, P., 1999, Transformations for "Calibrated image" creation using camera reports and distortion models. *ISPRS Vol XXII Part 5W11, Workshop "Photogrammetric measurement, object modeling and documentation in architecture and industry"*, Thessaloniki, Greece, 7-9 July, 1999. pp 215-219.
- Streilein, A., 1991, *Development of a Digital System for Architectural Photogrammetry*