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USE OF PHOTOGRAMMETRY IN 3D MODELING AND VISUALIZATION OF BUILDINGS

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ABSTRACT

3D Models of architectural structures are very important in order to study, analyze and also to reconstruct and document these structures. Visualization of these models allows the user to get the photo realistic impression of the structures than graphic based object models. 3D visualization has many applications in the areas of architecture, civil engineering, tourism etc. Normally, field surveys are more accurate than photogrammetric measurements; nevertheless, they involve more personnel and consume a lot of time. Photogrammetry is a measurement technology that can be used for the extraction of 3D points from images. The present paper highlights the project using photogrammetry for accurate 3D modeling and visualization of structures.

Keywords: 3D modeling, visualization, photogrammetry.

1. INTRODUCTION

In its restricted sense, the term photogrammetry means the process of measuring images on a photograph. An integrated digital Photogrammetry system is defined as hardware/software configuration that produces photogrammetric products from digital imagery using manual and automatic techniques. Nowadays there is an increasing demand for full three dimensional data for planning, architecture, environmental analysis, tourism etc. (Jose Luis Lerma, Antonio Garcia, 2004). To depict the real conditions of the object, and to measure 3D of all the corners of the structure particularly the inaccessible points, creation of accurate 3D models are very much necessary. Recent years have seen a number of development in geometric modeling of historical monuments in 3D especially their structural details and textures (Mila Koeva, 2004). Close range Photogrammetry is a measurement technology that can be used for the extraction of 3D points from the images; further these points are useful for the accurate 3D modeling and visualization. Digital Photogrammetry derives all the appropriate measurements from the images itself rather than measurements directly from the objects. Due to the digital data flow, photogrammetry has now become an efficient alternative to the classical building measurement and reconstruction methods (Ulrike Herbig, Peter Waldhäusl., 1997).Sabry El-Hakim *et al.*, 2005, discusses the various 3D model generation techniques and shows the advantages of photogrammetric techniques over CAD based techniques.

For the present project, an experiment has been conducted to check the accuracy of the 3D model generated using the photogrammetric technique. The complete orientation and calibration is done automatically only based on the images. There were no markers, or any approximations used. The object selected is the Institute of Engineers building, located in the Indian Institute of Technology Roorkee campus area. In the project, the camera used is Kodak CX7300 and the processing is done using photogrammetric software package Photomodeler 5.

2. OPERATIONAL STEPS

In the frame of this work, the following activities were performed:

- Photo acquisition;
- Processing of photographs;
- 3D Model generation; and
- Texturing and Visualization.

2.1 Data acquisition

The data acquired may be either hard copy photographs taken with film cameras or digital photographs taken with a digital camera. If hard copy photographs are available, these photographs are to be scanned with high resolution scanner. Other way is to acquire digital data directly by means of digital CCD cameras. Nowadays high resolution digital cameras are available at reasonable prices which bypasses the step of scanning. The cameras are also classified into metric and amateur cameras. Close range digital methods based on images taken with amateur digital cameras are becoming more popular because of their economic aspects. As the cost of developing the photographs is null, any number of photographs can be taken and decided at the office to choose the best photographs required for the project.

The camera used in the project is Kodak CX 7300 digital camera. Before using the camera in the project, the camera needs to be calibrated, under required photographical conditions. Recovering 3D structure from images a simpler problem when the cameras used are calibrated, that is, the mapping between image coordinates and directions relative to camera is known. This mapping is determined by, among other parameters, the focal length and its pattern of radial distortion (Paul E. Debevec, 1996). The calibration of the Kodak CX7300 digital camera was performed using Photomodeler 5 self calibration module, using several images of a plane test field supplied with the software. The results of calibration are shown in Figure-1.

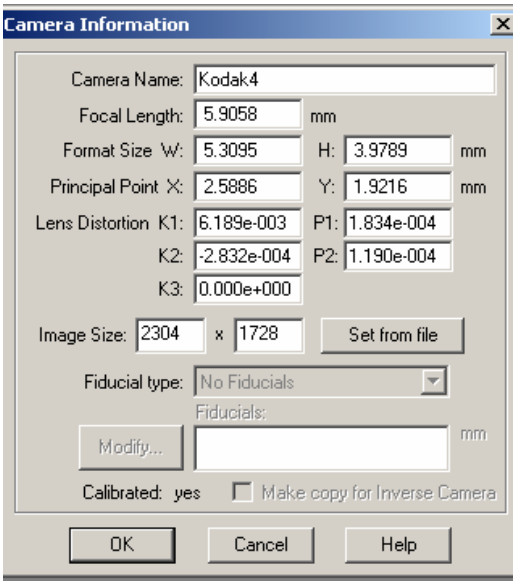

Figure-1. Camera information after the calibration.

PhotoModeler performed automatic camera calibration in 2 stages and the total error after calibration was 0.01 which is less than 0.02 (value indicating very good calibration for digital camera). After calibration of the camera, it was ready to take photographs. For a ideal photogrammetric survey, the base line/distance ratio ie., the distance between two camera positions while taking photographs to the distance between the camera to the object ratio should be within reasonable limits and not be too small and that should be between 1/15 and 1/20. If the building façade is large then camera is kept at large distance from the building (John Badekas, 1975). For best results, 3X3 rules were given by Waldhausl and Ogleby, 1994, which are to be observed for photography with amateur cameras.

Photographs are taken for the Institute of Engineers building and totally 35 photographs were used for the project taken at different positions around the building. The positions of the camera were carefully planned for the geometric accuracy of photogrammetric reconstruction of the project and to identify all points on photographs required for determination of the frame of reference and textural data of the object. Figure-2 shows the positions of camera maintained during data acquisition of the building.

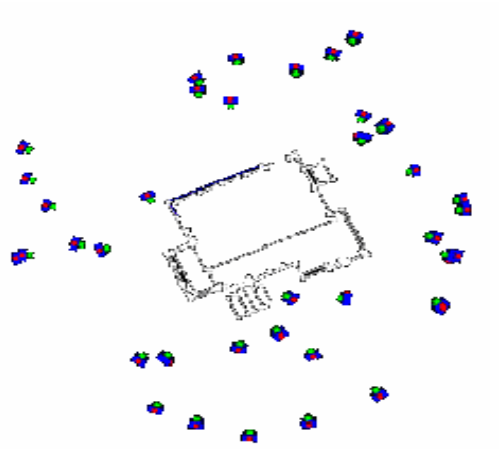

Figure-2. Positions of camera during data acquisition.

2.2 Data processing

The photographs acquired were imported into photogrammetric modeling software, Photomodeler. Reference points were selected on the building like corners which are easily identifiable and separable. The same points were identified on the building in the next photograph. Similarly all the salient points were identified around the building and each point is referenced in all the photographs. This process is known as orientation. Figure-3 shows the reference point selected over the photographs.

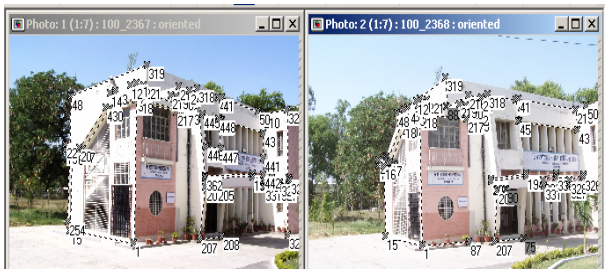

Figure-3. Orientation of photographs.

2.3 3D Model generation

3D model generation is typically done interactively to segment the points into separate objects and also to edit the output. For large environments, since the technique may require large number of images, model generation still necessitates significant human interaction, regardless of the fact that 3D point coordinates were computed automatically (Sabry El-Hakim *et al.*, 2003). A 3D model without surfaces or textures is a wireframe model. The wireframe model represents the building as a quantity of vertices and edges. This representation is true if one is interested in the general form of the building. Figure-4 shows the 3D model of the building.

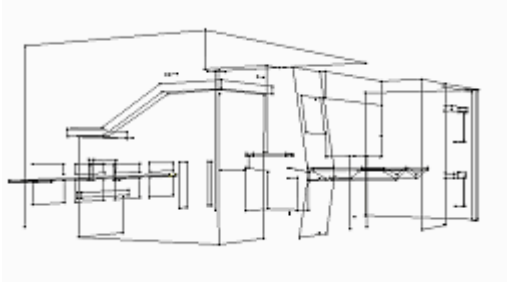

Figure-4. 3D wireframe model of the building.

2.4 Texturing and visualization

3D Wireframe model is just the line drawing and gives the shape of the building. To get the realistic impression of the building, textures are added for each side of the building. Textures give a new quality to a 3D model making it more similar to real object and more adequate for human perception and understanding. Textures can be assigned automatically by selecting an image with the best visibility or manually by picking proper face on the desired image (Ildar, 1999). The final output of textured object 3D model is shown in a VRML (Virtual Reality Modeling Software) format. Figure-5 shows the 3D textured model of the building.

Figure-5. Textured 3D model of building.

3. ACCURACY ASSESSMENT OF THE MODEL

The quality of the model is assessed by the residuals between the image coordinates marked on the images by the user and the image coordinates calculated using calibration of the cameras. Table-1 shows the RMS values of some points in the model which depicts the accuracy achieved in the project.

Table-1. Accuracy assessment of some points in the model.

Id	X	Y	Z	X Precision	Y Precision	Z Precision	RMS Residual (pixels)
1	3.1029	1.1521	8.9341	0.0022	0.0015	0.0024	1.3309
3	3.0325	1.1207	8.7921	0.0020	0.0013	0.0022	1.1926
4	3.0289	1.2502	8.7937	0.0019	0.0013	0.0022	1.0779
11	2.9963	1.3990	8.9492	0.0020	0.0013	0.0021	1.4736
12	3.1058	1.3995	9.0993	0.0023	0.0014	0.0023	1.6679

In Table-1, Id is the point identification number for some points used during referencing, XYZ values are model coordinates calculated during processing and XYZ precision values shows the marking accuracy, and the last column, the RMS residual value in pixels, achieved in the project. As per the guidelines of the photomodeler, (Photomodeler Pro 5 Help) for a good photogrammetric project, RMS residual value should be less than 3. The RMS value achieved is less than 1.5 for all the points, which is a good value for a project.

4. CONCLUSIONS

The above model demonstrates the use of Photogrammetry in accurate 3D modeling and visualization. The precision obtained in the 3D models corresponds perfectly which is required for any further work like reconstruction etc. Due to the availability of digital cameras in the market at reasonable costs, Photogrammetry offers the best alternative technique to any other CAD based techniques used.

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