RECONSTRUCTION AND REPRESENTATION
IN VIRTUAL REALITY OF A 3-D MODEL

Hao-Hsiung Huang

Department of Land Economics, National Chengchi University
64, Sec. 2, Zhi-nan Rd., Wenshan, Taipei, 11623, Taiwan, R.O.C.
hhh@nccu.edu.tw

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ABSTRACT:

3-D building models will be broadly constructed in a digital 3-D city map in the future. The models can be reconstructed using either aerial images or existing 2-D digital topographic map accompanied with height data. However, for large scale mapping, a more reliable and real 3-D model will be reconstructed using close range images. In this research, several close range images for a yard have taken by a calibrated digital camera. These images are used to reconstruct the yard model, also used for texture mapping of the yard. The resultant 3-D model has been represented in Virtual Reality Modelling Language(VRML). The visual appearance of the building model was high attractive.

1. INTRODUCTION

3-D building models have been attractive for a long while, especially when they have been represented in Virtual Reality. Usually, the models are reconstructed using satellite or aerial images or a scanned topographic map using height data. How accurate the reconstructed model is? Can it be suited for large scale mapping using a convenient digital camera? The primary purpose of the study has been to reconstruct a 3-D model using images taken by a digital camera. Experiments, generation of a 3-D model, generation of virtual reality, and testing with ground true are described respectively in the subsequent sections.

2. EXPERIMENTS

2.1 Image Acquisition

A Kodak DC280 digital camera was used for image acquisition. It is a non-metric camera, therefore, has been calibrated using the software, PhotoModeler Pro 4.0. The elements of interior orientation, including calibrated focal length, principal point location, radial lens distortion, and decentering lens distortion have been determined.

An outdoor yard was selected as study object. Fifty five images were taken, ten of them were chosen for model reconstruction. Four images are shown in Figures 1, 2, 3 and 4 respectively. Geometric configuration and convergent angles have been considered while the pictures were taking.

2.2 Ground Control

Ground control has been performed in a local vertical coordinate system using a total station. For verifying the accuracy of the resultant 3-D model, 31check points were also surveyed in the same coordinate system. These points were well distributed throughout the test area. Marks have been stuck on these points before taking pictures, so that their corresponding images could be recognized easily.

3. GENERATION OF A 3-D MODEL AND VIRTUAL REALITY

The test area contains several different types of objects, object points, edges, curves, cylinders, lines, and surfaces. All of these objects have been processed in three steps to generate a 3-D model:
1. The locations of objects are marked on each picture.
2. The points are referenced together.
3. The entered information is then processed.

A 3-D model generated by the PhotoModeler can be exported and saved in the following types of file: Autodesk DXF, Microsoft DirectX, 3D Studio, Wavefront OBJ, VRML, IGES, and Raw. Usually, some or all of the following data can be exported: 3D points, point IDs, edges, lines, faces surface draw, curves and cylinders.

Cosmo Player software supports the VRML file. The software can also be used for browsing a Virtual Reality Model in web. Therefore, the 3-D model built is exported and saved in a VRML file.

Although a Virtual Reality Model can be observed in any view angle, only four models displayed in browser are shown in Figures 5, 6, 7, and 8 respectively. For comparing, Figure 5 and Figure 1 have similar view angle, Figure 6 and Figure 2 have

Figure 1. Original Image 1

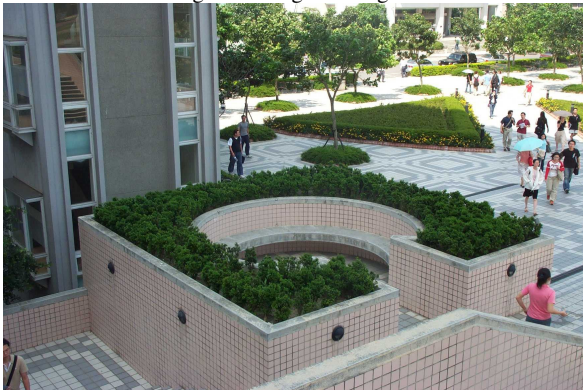Figure 5. Reconstructed Model 1

Figure 2. Original Image 2

Figure 6. Reconstructed Model 2

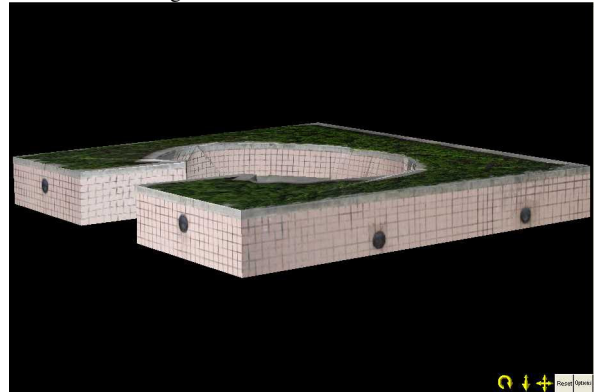Figure 3. Original Image 3

Figure 7. Reconstructed Model 3
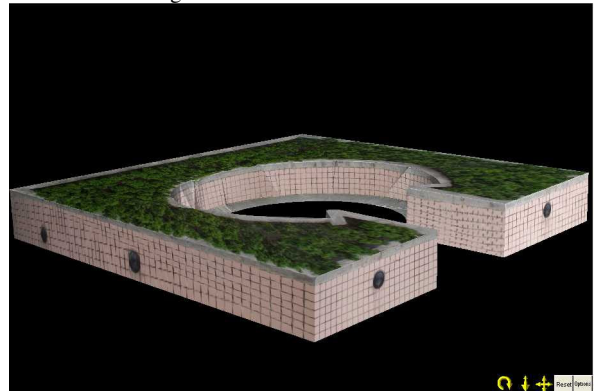

Figure 4. Original Image 4

Figure 8. Reconstructed Model 4

similar view angle, and so on. Compare with each other of the Figure pairs, one can access the effectiveness of reconstruction of the 3-D model.

4. TESTING WITH GROUND TRUE

For verifying the geometric characteristic, the 3-D model has also been exported and saved in a 3-D DXF file. The DXF file is then imported to the AutoCAD software, and a DWG file is drawn as shown in Figure 9.
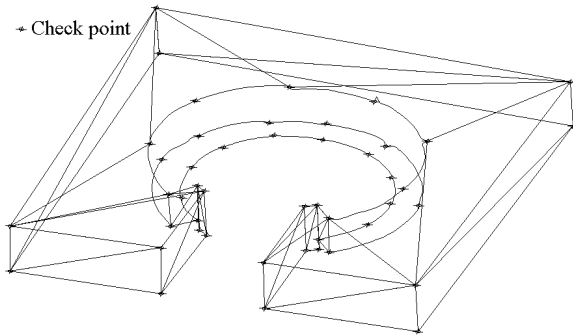

Figure 9. Reconstructed CAD Model

3-D coordinates of the check points in Figure 9 can be queried using AutoCAD. As stated above, 3-D ground coordinates of the check points were also surveyed using a total station instrument. The differences of the two sets of coordinates are shown in Table 1. As Table 1 demonstrates, the RMSE of ΔX, ΔY, and ΔZ coordinates are ± 0.033m, ± 0.070m, and ± 0.029m respectively.

5. CONCLUSIONS

Pictures and ground control are two of the most important items in generating and reconstructing a 3-D model. When taking pictures, the convergent angle between the exposure stations should be close to a right angle. However, if the pictures are used for texture mapping, the camera axis should keep nearly perpendicular to object surface.

When generating the 3-D model, reconstruction of curved edges and surfaces is not an easy work. Take a vertical picture and a parallel picture for a curved edge and surface is recommended.

Each picture should cover as many control points as possible. In this study, although 34 points have been surveyed in field, but only 3 of them appear on the most pictures. Therefore, the three points are selected for ground control points, the other 31 points are used for check points.

As shown in Table 1, the RMSE of Y coordinates is near twice of those of X and Z coordinates. This is reasonable for the terrestrial and close range images taken in this study.

Point	ΔX(m)	ΔY(m)	ΔZ(m)
1001	-0.026	-0.060	-0.006
1002	-0.037	-0.102	-0.041
1003	-0.011	-0.003	-0.009
1004	0.109	0.004	-0.087
1005	-0.023	-0.011	0.065
1006	-0.014	-0.056	0.021
1007	-0.012	-0.018	0.018
1008	0.001	-0.010	0.014
1009	-0.010	-0.035	0.007
1010	-0.007	-0.020	-0.001
1011	-0.004	-0.018	0.000
1012	-0.011	-0.031	-0.008
1013	0.016	0.003	-0.007
1014	-0.033	-0.049	0.032
1015	0.041	0.102	0.009
1016	-0.046	0.057	0.046
1017	0.003	-0.042	-0.009
1018	-0.014	-0.041	-0.036
1019	0.038	0.027	-0.007
1020	0.073	0.230	-0.009
1021	-0.051	0.191	-0.034
1022	-0.007	-0.030	-0.028
1023	0.014	0.010	-0.009
1024	0.027	0.040	0.005
1025	-0.002	0.028	0.025
1026	-0.021	-0.026	0.000
1027	-0.018	-0.054	-0.010
1028	0.029	0.008	-0.001
1029	0.013	0.039	0.021
1030	-0.008	-0.092	0.046
1031	-0.017	-0.040	-0.009
RMSE	0.033	0.070	0.029

Table 1 Coordinates Differences of 3-D Model and Field Surveying

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