

A METHOD OF BUILDING MODELLING FROM TRUE ORTHO-IMAGE AND DSM

JIANG Heng-biao^{a,*}, GUAN Hong-liang^{a,b}, LIU Xian-lin^{a,c}

^aCollege of Resource Environment And Tourism, Capital Normal University, Beijing 100037 ,China; ^bBeijing Peace Map Co., LTD, Beijing100037, China; ^cChinese Academy Of Surveying & Mapping, Beijing100037, China)

Keywords: Ortho-image; DSM; Building model; Triangulation technology

Abstract:

To create 3D vector building models is still a problem for most projects, the traditional way to do this is to extract the regular building borders from DSM, but the DSM precision always lower than the image, it is hard to detect the boundaries of building. Now the True Ortho-image comes, it should be existed a fast, efficient way to extract buildings border. A new method integrating DSM with True Ortho-image to construct terrain and building model is proposed in this paper. Because the boundary line of buildings is more precise and clear in True Ortho-image, we extract borders from True Ortho-image and automatically get evaluation information from DSM. After modelling buildings, it treats the building footprints as many holes on the ground, then triangulate the terrain polygon with constrained Delaunay algorithm. The final step is to do texture mapping with True Ortho-image texture.

* exljhb@126.com

1. INTRODUCTION

The traditional Ortho-images often ignore the height of the buildings, trees, bridges and other elevated objects. Because they don't correct the image drastically and the elevation differences lead to the pixel displacement, we can see the side faces of some objects on them (Figure 1(b)), which is difficult to draw the outline of the objects and model them. Another method draws objects outlines on the DSM and then reconstructs the 3D buildings, but the lower precision of the DSM brings more difficulties for the border orientation (Figure 1(a)).

Building modelling is one of the researched points in the digital 3D city reconstruction field. The general methods like land survey and aerial stereo images observation need a large number of people and material resources, and the efficiency is low, which cannot reflect the development of the city in time. So the traditional methods cannot satisfy the application requirement, it needs to develop new methods and technologies. The emergency of True Ortho-image (Figure 1(c)) makes it possible to draw the objects outlines on the images directly. So a new method integrating DSM with True Ortho-image to construct terrain and building model is proposed in this paper.

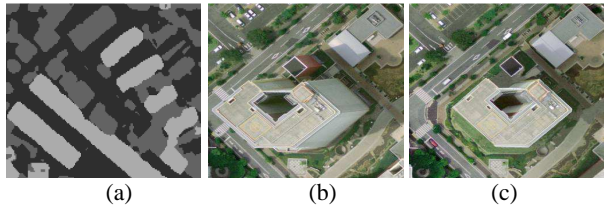


Figure 1. DSM, Ortho-image and True Ortho-image

2. THE PRINCIPLE OF TRUE ORTHO-IMAGE

True Ortho-image is a new conception relative to the traditional Ortho-image. As we all known, the traditional Ortho-images often ignore the height of the buildings, trees, bridges and other elevated objects, which need the DEM to correct it. However, True Ortho-image needs the DSM to correct itself. The production of the True Ortho-image needs large overlap of the images, which are over 60% overlap and side overlap (Figure 2). The correction principle is showed in figure 3, and the aim is to compute the pixel displacement (Niblack, 1985; Schickler, 1998; Amhar, 1998).

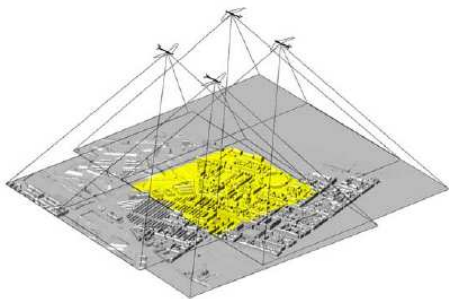


Figure 2. Multi-view image with over 60% overlap (Nielsen, 2004)

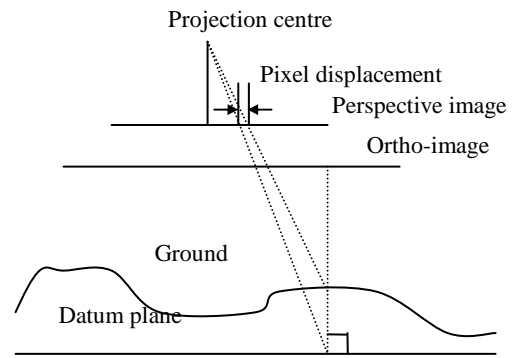


Figure 3. The perspective principle of image

3. THE NEW METHOD FOR CONSTRUCTING BUILDING MODEL

The city buildings have certain regular shape, obvious borders, difference in height, shade under sunshine, and some obvious traits contrast surrounding environment, etc. So people develop many methods to extract the buildings from the remote sensing images automatically. However, these methods are influenced by image quality and texture, which makes it difficult to extract the buildings perfectly, leads to complicated homework procedure and low precision (Brum, 1998; Huertas, 1988; Hiroshi, 1999).

With the True Ortho-images comes, a new method to extract the boundaries of city buildings precisely and fast comes true. Because the image correct with DSM, the borders of the buildings is clear and the building's roof projection shape on the ground without displacement. Perfect DSM will make perfect True Ortho-images. We can utilize vector shape coordination to correspond with that of DSM. It is possible to create more precise 3D buildings in such a way.

3.1 Extract roof vector shape based on True Ortho-image

The city buildings boundaries can extract by some image process algorithms such as edge detection operator, regional growth and so on, then the pixels link together and make a straight line of the border. It is difficult to do this automatically on the image and cannot get satisfy results, so our method is semi-automatically and needs interfere of operators (Figure 4). After tracing the buildings boundaries with some plotting tools, it can get a vector shape file without Z value but with X, Y value.

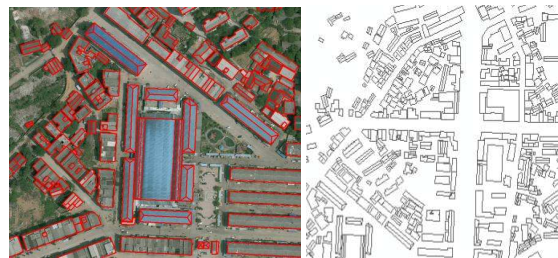


Figure 4 Building footprints on True Ortho-image

3.2 Get the Z value from DSM and DEM

To create 3D building models, it must get Z value from DSM. The place of the elevation point can calculate by equation 1. We get the buildings surface elevation from DSM and the ground

elevation from DEM. As you can see that equation 1 will calculate the position and equation 2 acquire the Z value.

$$\begin{bmatrix} X \\ Y \end{bmatrix} = \begin{bmatrix} X_0 \\ Y_0 \end{bmatrix} + \text{cellsize} \begin{bmatrix} \text{column} \\ \text{row} \end{bmatrix} \quad (1)$$

X_0, Y_0 is the down-left corner point coordination of DSM and DEM. Cellsize tells the resolutions of DSM and DEM.

$$Z=f(X,Y) \quad (2)$$

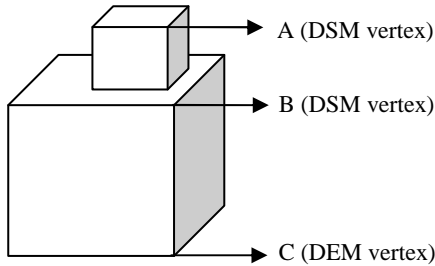


Figure 5. Get the elevation value from DSM and DEM

3.3 Process buildings' roof

It is unreliable and unsafe to get the elevation information from buildings corner points because elevation value of boundaries will change dramatically. It cannot ensure that the height value is the roof or ground, some of the roof is not level, such as tilted triangular roof surfaces are common at home and abroad. More reliable approach is to obtain plane equation of the roof after triangulation (eq. 3), then check if it is level get the averaging of three vertices value to represent the plane height (eq. 4), if it is tilted triangular face, calculating the plane equation of a shrink triangle (Figure 7), then getting the three vertices height value from DSM. This method is more reliable, can get the roof value not the footprint value of buildings. Figure 5 shows the vertex value where can get. Figure 6 shows the roof polygon triangulation. You can see the result model on figure 8 after extruding roof polygon.

$$AX+BY+CZ+D=0 \quad (3)$$

$$\bar{X} = \sum_{i=1}^3 X_i, \bar{Y} = \sum_{i=1}^3 Y_i \quad (4)$$

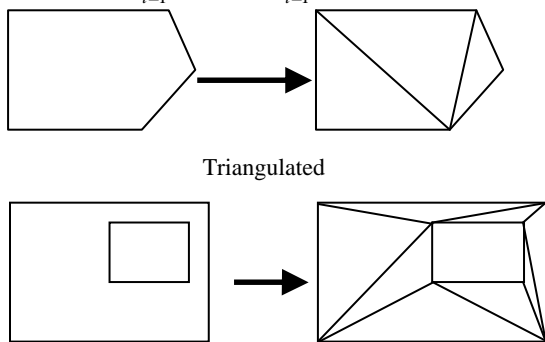


Figure 6. Roof triangulation

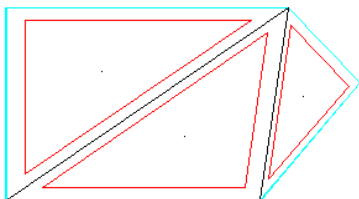


Figure 7. The red line indicated shrink triangles

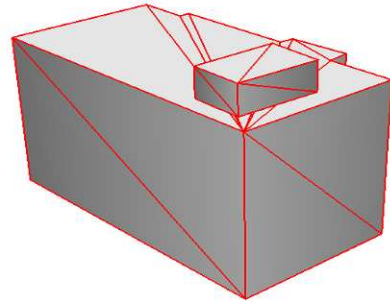


Figure 8. Extrude the roof after get the height value

3.4 Process the ground

After extracting the borders of each building and calculating the buildings vertices height of DSM and DEM, we treat the footprint of the buildings on the ground as holes (the red part of Figure 9), then constrained Delaunay triangulation algorithm is applied on the whole scene. Figure 10 shows the results (buildings integrated with ground triangulation). In this way, buildings model and the terrain model are processed separately.

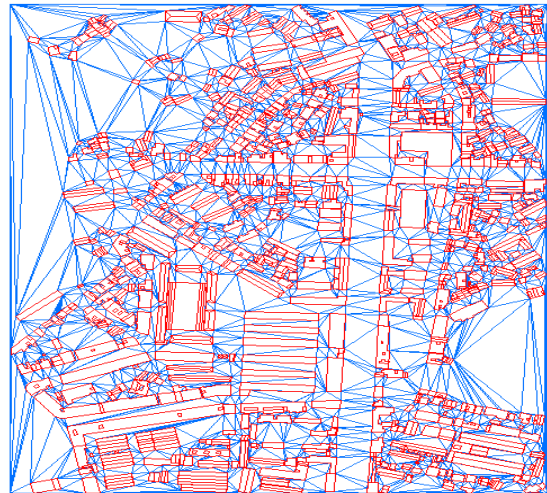


Figure 9. Triangulated ground with holes (buildings)

3.5 The data structure of 3D buildings

In 3D GIS, the model of integration TIN and CSG has been extensively studied, which effect is more desirable in practical applications. We also use a similar method in that a large ground-based object model is described by TIN. Compared with the regular grid, TIN has higher accuracy to describe complex surface and few data (LiQing-quan, 2000). Our method is similar to the CSG building structure. These regular buildings surfaces are expressed with triangular faces. Complicated buildings need more triangles to describe the surface. Building surfaces can be simply divided into top, side, and bottom face. The storage order of surface data is (top + side), neglected the bottom. In general, the bottom is overlap with the ground, no need to describe the bottom.

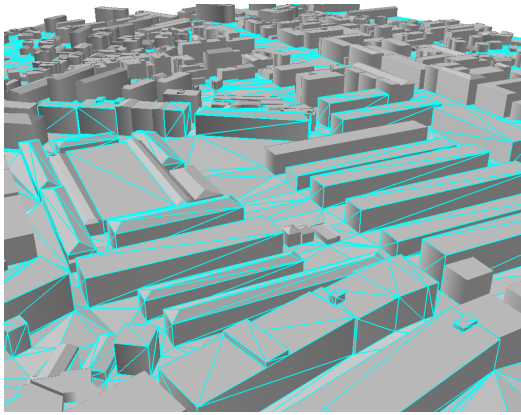


Figure 10. 3D model structure of TIN plus CSG

4. TEXTURE BUILDING MODELS WITH TRUE ORTHO-IMAGE

From the second part of this paper, we know the generation principles of True Ortho-image. There is a close relationship between True Ortho-image and DSM. Building surfaces coordination is obtained from the True Ortho-image which has the same position in DSM. Under the direct relationship, it can make an overall texture mapping on the top surface of the whole scene, such as in Figure 11, the upper part is the scene model, and the lower part is Ortho-image, so that the roof surface texture and surface texture mapping will be automatically carried out separately, reduce the workload, but express a nice 3D model of the whole scene. Figure 12 tells the effect after the completion of automatically mapping, we can see that the roof surface texture is located on the top surface of the building, ground part located on the ground surface, side faces without texture.

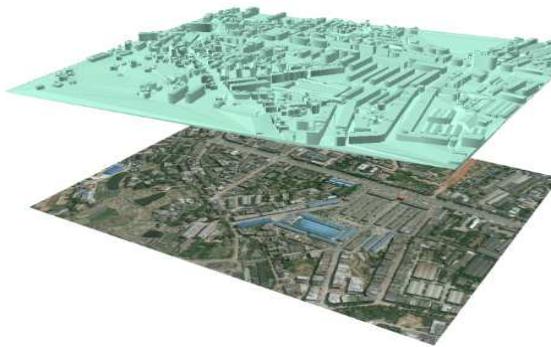


Figure 11. Buildings models related with True Ortho-image



Figure 12. Effect after texture mapping

5. CONCLUSION

This paper discusses the application of the latest photogrammetry technology products, the True Ortho-image and DSM. Compared to traditional Ortho-image, True Ortho-image has more advantages and the coordinates on the image are more precise. It is believed that which will play a great role in the 3D surface model reconstruction. The method presented in this paper has a significant value in mapping fields, can be widely used in fast 3D modelling of buildings and improve the efficiency.

REFERENCE

Amhar, F., et al. 1998. The Generation of True Orthophotos Using a 3D Building Model in Conjunction With a Conventional DTM. IAPRS, Vol.32,p.16-22.

Brum A, Weidner U. 1998. Hierarchical Bayesian nets for building extraction using dense digital surface models. ISPRS Journal of Photogrammetry & Remote Sensing, 53(5): 296-307

Hiroshi M, Hiroyuki H, Izumi K. 1999. Extraction of building shapes from laser scanner data using region segmentation method. International Workshop on Vision-Based Techniques in Visualization and Animation, Onuma, Japan.

Huertas A, Nevatia R. 1988. Detecting buildings in aerial images. Computer Vision, Graphics, and Image Processing, 41(6):131-152

LiQing-quan, 2000. *The real-time acquisition, modelling and visualization of 3D spatial data*. Wuhan University Press, pp.352-367

Niblack, W., 1985. An Introduction to Digital Image Processing, Strandberg.

Nielsen, M., 2004. True orthophoto generation. IMM-THESIS: ISSN 1601-233X, Informatics and Mathematical Modelling, Technical University of Denmark.

Schickler, W., 1998. Operational Procedure for Automatic True Orthophoto Generation. International Archives of Photogrammetry and Remote Sensing, 32(4):p.527-532.