

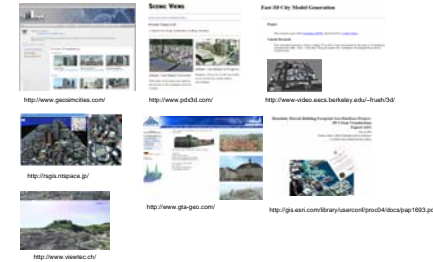
3D Downtown Phoenix Modeling

ABSTRACT

This project is to develop the efficient and effective method for creating 3D city models that will be used with GIS (Geographical Information Systems) data in VR (Virtual Reality) environment. Here introduces the modeling process to create 3D city model from aerial photos, and shows the result of 3D downtown Phoenix model. The multiple angle shots of downtown Phoenix were taken at an altitude of 6,000 feet. Two oblique shots with about 30 degree and one vertical shot were used. The 9 inch x 9 inch films were scanned with 2000 dpi. The building extraction software generated the 3D polygon data for the ground and the buildings using the technology of photogrammetry and 3D vision. The textures for buildings were automatically created from the aerial images at the same time when the height and shapes of buildings were extracted. The model was saved as 3DS formatted file, which is one of the standard formats in 3D CG, and transformed fitting to the geo coordinate using the information of longitude and latitude acquired from Google Earth. Finally, the 3DS file was converted to OSG formatted file to visualize in VR environment at ASU Decision Theater.

Background

3D City Modeling is one of the most interested topics in GIS, CG, Architecture, etc. A lot of researchers are finding out the best way to create 3D city models.



Modeling Process

1. Take Aerial Photos from 6000ft
 2. Scan the photos with 2000dpi
- Rupp Aerial photograph

Nverse (3DS Plug-in software)

3. Register Camera Views
 - 1) Load images
 - 2) Set the camera parameters and scanned information
 - 3) Create a few polygons for buildings in one image
 - 4) Specify the positions in the other images
 - 5) Create a few ground points for each image

* The ground object texture-mapped with orthoimage is automatically generated.
4. Model Buildings
 - 1) Create each polygon for each building.
 - 2) Edit the corresponding polygons in the other images

* A 3D object for each building is automatically generated as an editable mesh object for 3D Studio Max. The side image (texture mapping) is also calculated at the same time.
5. Get Geographical Information

By assigning the latitude and longitude values for each ground truth point, which are created in the Step3, the 3D objects including the ground and buildings are transformed as a real scaled model.

* There is an option to use 3D digital elevation model (DEM) from USGS.

- 3D Studio Max
6. Edit 3D Objects using UV Map

- ASU Decision Theater
7. Translate MAX file to OSG file

Aerial Photos

In this project, several different kinds of aerial photos were taken for testing. The images taken by the most advanced digital camera were not useable, even though they were taken from the helicopter at the altitude of 1000ft. 3 standard aerial photo films (9" x 9") were used finally. One is vertical shot, and the other two images are oblique shots with 60 degree to the ground. The altitude was about 6000ft from the ground.

Scanned Images

Each aerial photo is scanned at most with 2000dpi, and saved as TIF format without any compression. Each scanned image has 18,000 x 18,000 pixels.



Camera Registration

A plug-in software for 3D Studio Max, Nverse-Photo 2.7 (Precision Light Works 2006) is used to model 3D buildings and the ground.

Camera View is specified by inputting the following values.

- 1) Calibration Focal Length: 152.884mm
- 2) Lens Distortion:

$$K_0 = -0.2877 \times 10^{-6}$$

$$K_1 = 0.8168 \times 10^{-8}$$

$$K_2 = -0.4265 \times 10^{-22} \quad K_3, K_4 = 0.0000$$

- 3) DPI: 2000 dpi
- 4) X and Y offsets of Image using fiducial marks

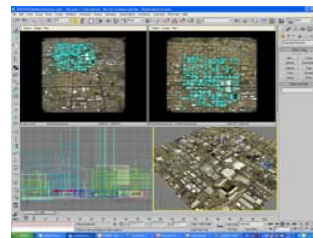
Create 3-5 polygons and 4-6 points for sampling

- 1) Draw a polygon as a boundary of building in one image.
- 2) Send the polygon to the second image and edit the polygon corresponding to the building in the second image.
- 3) Repeat 1) and 2) several times.

After camera settings and sampling are done, NversePhoto calculates the best fitting view point for each image. If the error is big, add more polygons.

Graphical User Interfaces (GUI) of Nverse Photo plugged in 3DS Max

- Once camera registration is done successfully, it is required only to
- 1) draw a polygon for each building in the first image,
 - 2) Send the polygon to the second image, and edit the points to fit to the building in the second image.



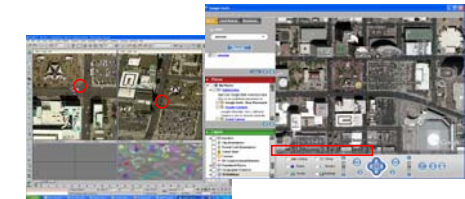
Texture Mapping

One of the strongest features in NversePhoto is to generate Orthoimage for ground and side texture-mapping images for buildings automatically.



Google Earth

Google Earth is a computer-based tool to browse maps and aerial images in both vertical and perspective views (Google Earth 2006). It has a very useful function to display the longitude and latitude of point on the image. By using this function, it is possible to assign the real location of points in Nverse Photo, even though the point is not a ground truth point.



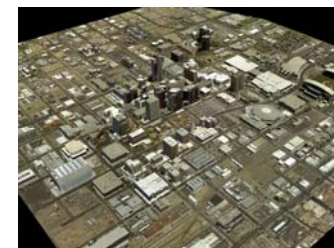
Editing 3D Model

3D Studio Max (Autodesk 2006) is one of the most professional 3D computer graphics modeling and rendering packages, and it was used to edit the details of buildings. It happens that some side images are not seen from airplane. In that case, the images taken from the ground can be used. UV-mapping, which is one of the most advanced techniques commonly used in developing 3D games, is applied to edit the side images of buildings.



Downtown Phoenix Model

The model covers about one square mile area in the center of downtown with more than 700 buildings, which were created within 16 hours by one specialist who trained the modeling method with professional 3DS Max knowledge.



Demonstration in VR (Virtual Reality) Environment

The downtown Phoenix model developed in this project is also demonstrated at ASU Decision Theater. (<http://dl.asu.edu>) They are now developing downtown Tempe model using the technologies presented here. The model created in 3D Studio Max is usually saved as .max format. ASU Decision Theater use .osg (Open Scene Graph) format to show the 3D models using stereo view with 3D glasses.



Conclusion and Future Works

• It was demonstrated that a realistic 3D city model could be created in a short time with a little labor by using the current technology of photogrammetry and computer graphics.

- Future works are to
- 1) find the method to create more realistic details for architectural design evaluation,
 - 2) develop a decision support system with GIS data in VR environment, and
 - 3) expand the covering area.

References

- Precision Light Works, 2006. <http://www.precisionlightworks.com/>
 Autodesk, 2006. <http://www.autodesk.com>
 USGS, 2006. <http://edc.usgs.gov/>
 Google Earth, 2006. <http://earth.google.com/>
 Open Scene Graph, 2006. <http://www.openscenegraph.org/>