Extraction and 3D Visualization of Trees in Urban Environment

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Abstract: Recently 3D city models are required for many applications such as urban microclimate, transportation navigation, landscape planning and visualization to name a few. The existing 3D city models mostly target on modeling buildings, but vegetation also plays an important role in the urban environment. To represent a more realistic urban environment through the 3D city model, in this research, an investigation is conducted to extract the position of trees from high resolution IKONOS imagery along with Airborne Laser Scanner data. Later, a tree growth model is introduced to simulate the growth of trees in the identified tree-positions.

Keywords: tree extraction, virtual city model, 3D modeling

1. Introduction

Environment issue is one of most essential factors for human sustained development. Many studies have been conducted about environment, especially natural environment. But, as the most concentrated region of human intensive activities, urban area and its environment have very direct and important influences on people's daily life. So, recently 3D city models are required for many applications such as urban microclimate and transportation navigation, landscape planning and visualization to name a few.

The studies about 3D city model have been conducted. Haala and Brenner (1999) combine multiple spectral imagery and laser altimeter data in an integrated classification for the extraction of buildings, trees and grass-covered areas, and reconstruction buildings using laser data and 2D ground plan information[1]. Guo Tao (2003) generates 3D city model from IKONS image and Airborne Laser Scanning data[2].

These 3D models mostly target on modeling buildings, but vegetation also plays an important role in the urban environment. To represent more realistic urban environment through the 3D city model, in this research, an investigation was conducted to extract the position of trees from high resolution IKONOS imagery along with Airborne Laser Scanning (ALS) data. Later, a tree growth model is introduced to generate 3D tree model. And then the 3D tree model is put in the identified position in the 3D city model.

2. Data Description and Test Site

1) Input Data

・**IKONOS images** have been preprocessed by Japan Space Imageing(JSI). All images have ortho-rectified by using ground control points (GCPs). The ground positioning accuracy (RSM) is 1.75m. The resolution of multi-spectral (R, G, B, NIR) is 4m and panchromatic image has 1m resolution. Due to the 11-bit color depth, IKONOS images contain a wider dynamic spectral range.

・**ALS data** provided by JSI is originally captured from ALTMS system (manufacture is TerraPoint, built by HARC with NASA support). The average sampling space of laser points in about 1.5m and the size of footpoint of laser beam on the ground is 90cm, elevation accuracy is 15cm and horizontal accuracy is about 1m.

2) Test Site

Test site is set up Shinjuku area in Tokyo. The acquisition date of ALS data is in Feb.2000, and IKONOS image was acquired in Nov.4th, 2001. Shinjuku is one of biggest commercial centers of Tokyo, and is a typical downtown of big cities.

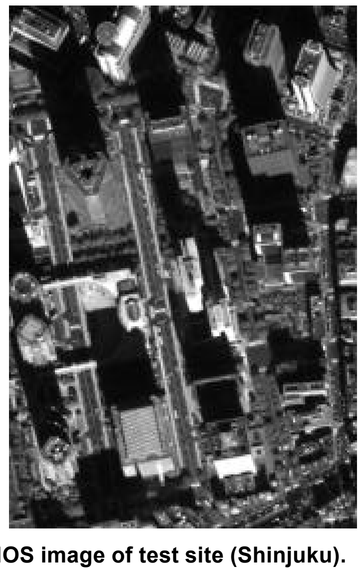


Fig. 1. IKONOS image of test site (Shinjuku).

3. Methodology

1) Tree-Point Extraction

This process has 2 steps to extract the points of trees. The first step is to extract tree-area from the image. The second step is to identify a tree position from the extracted.

a) Tree-area extraction

Firstly, to separate vegetation area and non-vegetation area, Normalized Difference Vegetation Index (NDVI) was calculated in this research. NDVI is defined as (1):

$$NDVI = (IR-R)/(IR+R) \qquad (1)$$

Where IR is Near Infrared band and R is visible red band of each pixel.

Normally in urban environment, vegetation has high NDVI value, bare soil has medium value and road and buildings have low value. So, the area where the value of NDVI is high is vegetation area.

Secondly, the extracted area is masked in reference to ALS. Setting the threshold for the height, the extracted area was masked.

The masked area is tree area. That is the area with both high NDVI value and high value of the height is tree area (Fig.2).

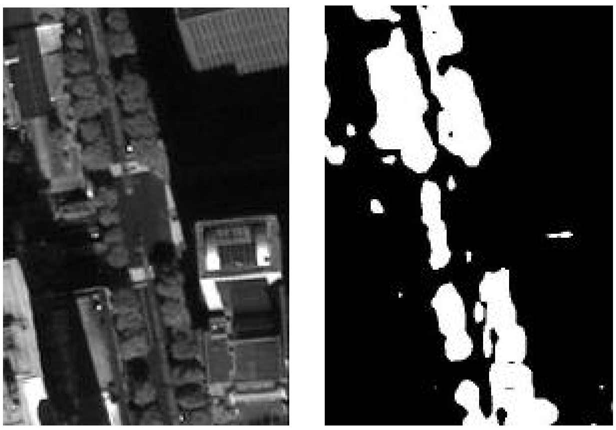


Fig. 2. Tree Area Extraction. : The left is original IKONOS panachromatic image. The right is tree potential areas.

b) Detection of tree-point

In order to define the position of single trees within the extracted tree area, a skeleton was calculated for these areas (Fig.3a). It is considered that tree-points are on the skeleton line. And, assuming that the point of the canopy top is the point where a tree is located, the tree-point is the point on the skeleton line that is the highest in the neighborhood. So, Local Maximum (LM) filter was applied to the skeletonized images. In LM filtering, a window is passed over all pixels in an image to determine if a given pixel is of higher value than all other pixels within the windows[3][4]. Pixels identified as the largest value within the windows are noted as tree locations (Fig.3b).

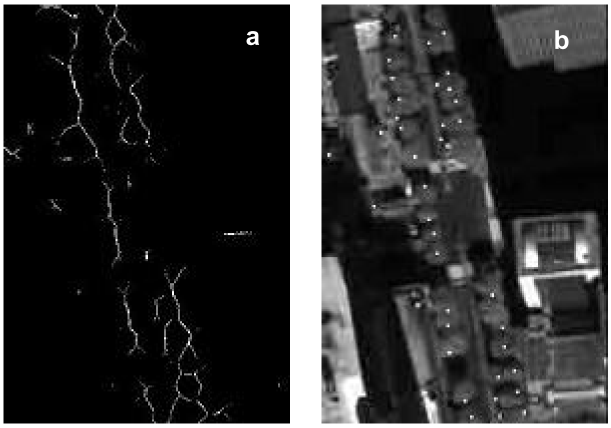
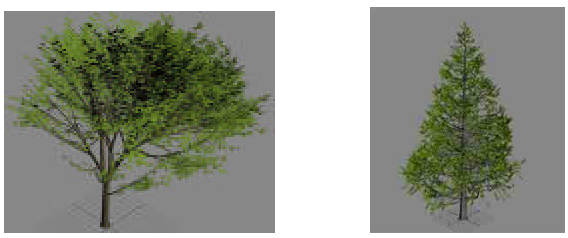


Fig.3. Tree point Detection : The left is the skeleton of the tree area. The right shows the identified point of trees. The white points are the tree points.

2) Generating 3D tree model

3D tree models were generated using natFX, which can model a lot of types of plants, including flowers, bushes and trees. And it can also generate 3D models of a given plant at different ages and at different seasons. NatFX is based on AMAP (Atelier of Modeling of Architecture of Plants) and developed as a plug-in software for "3ds max" (Descreet), which is 3D modeling software. In this research, simulation of tree growth generating of 3D tree model, and 3D city modeling are conducted on 3ds max (Fig.4).

Tree growth simulation was conducted to estimate the age of tree from the height of tree. Figure 5 shows the relation between the age and the height of *Gingko biloba*. It can be approximated to linear relation. By using this relation, the tree age can be estimated from the height data got from ALS data.



Zelkova serrata ***Ginkgo biloba***

Fig. 4. 3D tree model generated on 3ds max.

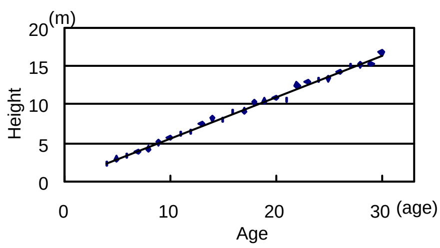


Fig. 5. Relation between Age and Height of *Ginkgo biloba*.

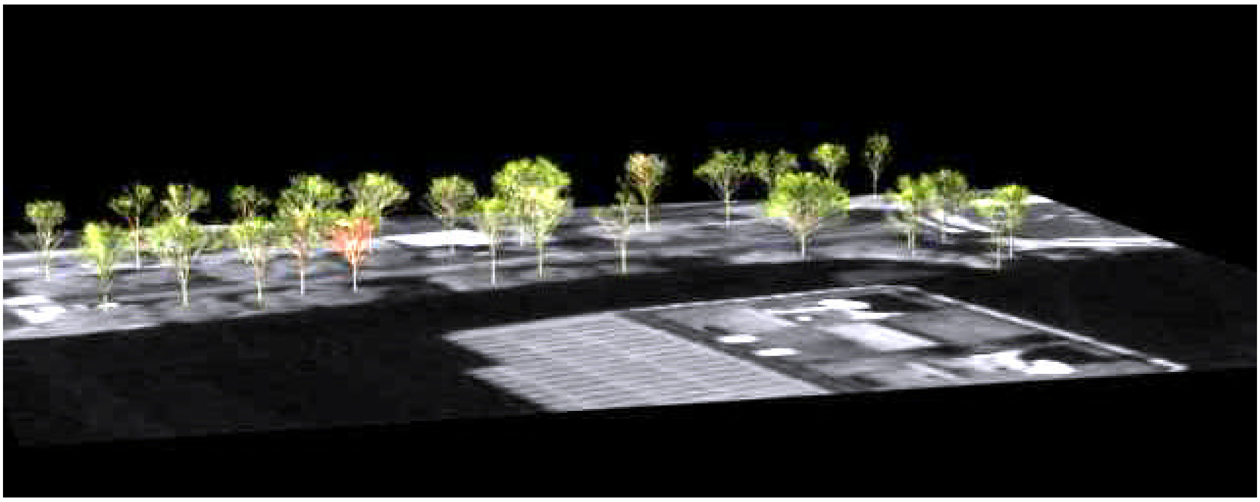


Fig. 6. 3D tree models on the IKONOS Image (perspective view).

3) Visualization of Urban landscape

The program was developed to place 3D tree model at the identified point. In this program, ASCII data consisted of five fields, X-, Y-, Z-coordinate, tree species and age estimated from the height data, is loaded. The data of species of roadside trees is listed in the ledger of greening roads, which is made by Tokyo Metropolitan Government Bureau of Construction, and the other tree data is got from field investigation. And a 3D tree model was selected randomly from ten objects generated beforehand for each age. Then the selected model was arranged at the (X,Y,Z) point.

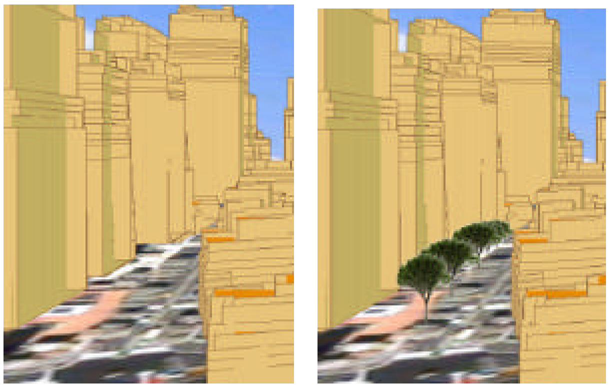
By this means, 3D tree models were placed in the identified point. Figure 6 and 7 shows 3D tree model put on the original IKONOS panchromatic image.

Conversion program was developed to convert the data of the existing model (Guo Tao's model) into 3ds max format. In this program, the 3D building model expressed by text data was available for 3ds max (Fig.8).

Fig.7. 3D tree models on the IKONOS Image (eye height view).

4. Conclusions

Experiments conducted in the research show a good performance in positioning urban trees and the visualization of 3D city model is improved by introducing the 3D tree models. But it leaves some to be improved. There were some errors of identifying tree-point, for example over-detection and difference between true point and identified point.



Before After

Fig.8. The trees In the urban environment. : The left is the existing model and the right is the improved one.

References

[1] Haala, N. and Brenner C., 1999. Extraction of buildings and trees in urban environments, *ISPRS Journal of Photography & Remote Sensing,* 54:130-137

[2] Guo, T., 2003. 3D City Modeling Using High-Resolution Satellite Image and Airborne Laser Scanning Data, *Doctoral Thesis of the University of Tokyo*

[3] Dralle, K. and Rudemo, M., Stem number estimation by kemel smoothing of aerial photos. *Can. J. For. Res.* 26:1288-1236

[4] Wulder, M., Niemann, K.O and Goodenough D.G., 2000. Local Maximum Filtering for the Extraction of Tree Locations and Basal Area from High Spatial Resolution Imagery, *Remote Sensing of Environmen,*73:103-114