EXTRACTING OUTLINE AND ESTIMATING HEIGHT OF LAND FEATURES USING LIDAR DATA

Woo-Kyun LEE, Chul-Chul SONG

Division of Environmental Science and Ecological Engineering Korea University, Seoul 136-701 Korea, leewk@korea.ac.kr

ABSTRACT: Digital topographic map in Korea contains layers of spatial and attribute data for 8 land features such as railroads, watercourses, roads, buildings and etc. Some of the layers such as building and forest don't include any information about height, which can be just prepared by interpretation of remote sensed data or field survey. LiDAR(Light Detection And Ranging) data using active pulse and digital camera provides data about height and form of land features. LiDAR data can be used not only to extract the outline of land features but also to estimate the height. This study presents technical availability for extraction and estimation of land feature's outline and height using LiDAR data which composes of natural and artificial land features, and digital aerial photograph which was taken simultaneously with the LiDAR. The estimated location, outline and height of land features were compared with the field survey data, and we could find that LiDAR data and digital aerial photograph can be a useful source for estimating the height of land features as well as extracting the outline.

KEY WORDS: LiDAR, digital topographic map, building, forest, extracting outlines, estimating height

1. INTRODUCTION

Digital topographic maps in Korea have to be made based on a guideline, which is legally established by government. There have been two versions of digital maps since 1995 and the newer, called as version 2.0, has been prepared since August 2006.

The layer composition of the new digital map is different from that of the old version.

Table 1. Changes in legal layer composition

Version 1.0		Version 2.0	
code	feature	code	feature
1	railroads	A	transportations
2	watercourses	B	buildings
3	roads	C	facilities
4	buildings	D	vegetations
5	tributaries	E	waterbodies
6	facilities	F	topography
7	topography	G	districts
8	administrative districts	H	annotations
9	annotations	-	-

In digital maps based on the version 1.0, only the topography layers, such as contours and level points, had elevation values of land features. On the other hand, in the version 2.0, six layers, such as transportation, building, facilities, vegetation, waterbody and topography, have elevation values of their own land features.

The preparation of 3D digital map for the new version involves more complicated process and might be expensive and time-consuming.

This study is focused on technical availability for extraction of land feature's outline and estimation of height using LiDAR data which composes of natural and artificial land features in a mountainous area, and digital aerial photograph which was taken simultaneously with the LiDAR.

2. DATA COLLECTION

2.1 Study area

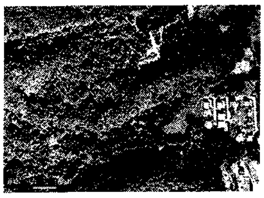
The study area was selected in Mt. Yumyeong, the upper left 127°29′7.8411′′E, 37°36′24.6731′′N and the lower right 127°29′30.2981′′E, 37°36′10.1305′′N, in Central Korea.

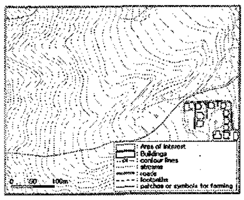
2.2 Materials

1) Currently used data
   - aerial photograph : scale 1/15,000, panchromatic band, taken before 1986
   - digital topographic map : scale 1/5,000

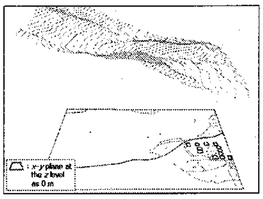
2) Field survey data
   - sample plot : four plots of 20m×25m
   - measurements : total heights and GPS location of individual tree stems, surveyed in 2004

3) LiDAR data
   - LiDAR system : Optech, ALTM 3070
   - digital camera : Emerge, DC 4K02
   - measurements : the first and last Laser pulse returns, digital aerial photograph, scanned at April 2004





(a) aerial photograph (b) digital topographic map



(c) elevation among feature layers
Figure 1. Currently used data.

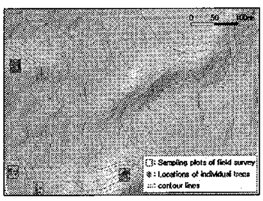
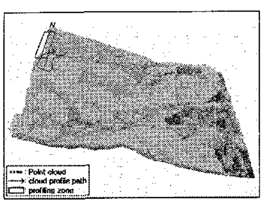
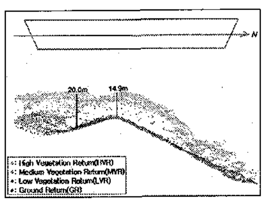
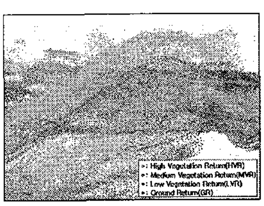


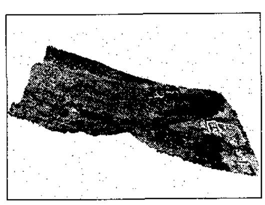
Figure 2. Field survey plots for estimating locations and heights of individual trees.





(a) point cloud (b) cloud profile





(c) classified points (d) ortho-photograph in RGB
Figure 3. Post-flight processed LiDAR data.

3. METHODS

Among the layers of a new digital, three kinds of layers (topography, vegetations and buildings) were selected to be extracted.

For data processing, ArcGIS, LiDAR Analyst, TerraScan and TerraModeler were used.

3.1 Elevation

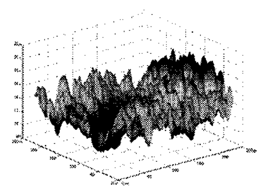
The contour of currently used map was processed to make DTM(Digital Terrain Model) of 5m×5m cells and LiDAR's DTM was also prepared using the pulses reflected from the ground among last pulses.

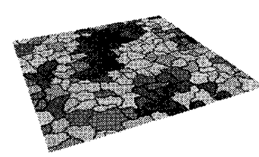
Then, the LiDAR's DTM was subtracted from that of currently used map. The basic statistics were calculated and t-test was executed under a hypothesis of equal variance between them.

3.2 Crown outline and height of tree

The DCM(Digital Canopy Model) was computed as the difference between first pulses and the DTM with each 1m pixel. Each height of individual trees was determined by the highest elevation values of the DCM in segmented polygons that were proved to be the crowns of individual trees. And we compared the tree heights from DCM with the tree height from field measurements.

The crown delineation was performed on the DCM using the watershed segment method for detecting the number of individual trees. Watersheds can be delineated from the DTM using the output from the flow direction function as the input to the watershed or basin functions. Both of these functions use a grid of the flow direction to determine the contributing area. The watershed segmentation could find the crown of individual tree and the edge of each crown.





(a) Digital Canopy Model (DCM) (b) segmented zones
Figure 4. Delineation concept using hydrological analysis functions.

3.3 Building outline

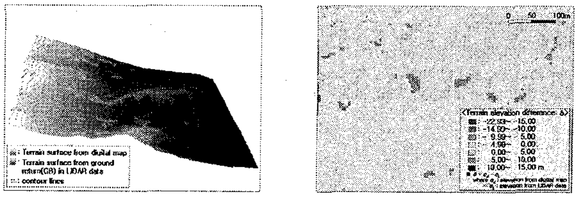
The building outline was extracted from last pulses using building extraction module and compared the building outlines on the currently used map.

The differences between the buildings outlines of LiDAR and currently used map were calculated and compared with the allowable error range of 1/5,000 scale map.

4. RESULTS

4.1 Elevation

The maximum was 22.926m, the minimum was 0m and the average of elevation difference between the currently used map and LiDAR's terrain surface was 1.107m. According to t-test, these two DTMs are proved statistically same.



(a) overlapped DTMs (b) ortho-photograph in RGB
Figure 5. Elevation differences between the old map and LiDAR's terrain surface.

4.2 Crown outline and height of tree

The mean value, the standard deviation and root mean square error (RMSE) of the tree height difference between filed-derived and LiDAR-measured individual trees were determined for the 135 trees measured. The average of the difference between field and LiDAR measured tree height was –0.09m. The standard deviation of the difference between field and LiDAR measured tree height was –0.05m and the RMSE was –0.01m. LiDAR shows relatively good performance in estimating tree height with the coefficient of determination of 0.79 (Figure 6).

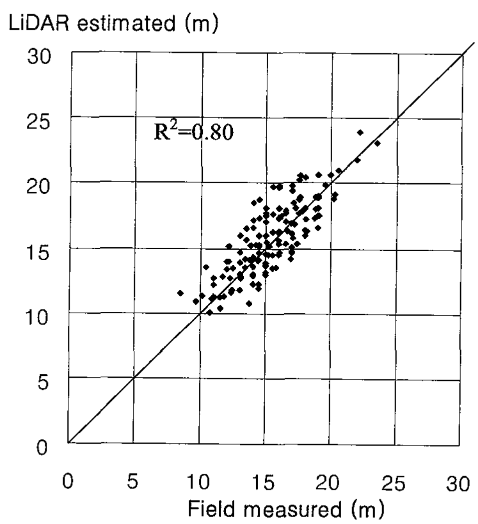


Figure 6. Accuracy analysis of the tree height

Table 4. Accuracies of the number of detected trees, tree height

Species	Statistics	Number of individual trees(N)			Tree height(m)		
		observed	predicted	difference	observed	predicted	observed
Total Species	Mean	9.00	9.47	-0.47	15.41	15.50	-0.09
	Std.	1.20	2.39	-1.19	2.68	2.73	-0.05
	RMSE	0.31	0.62	-0.31	0.40	0.41	-0.01

4.3 Building outline

Number of buildings from the old map was 12 and LiDAR's was 17. Buildings' number from LiDAR data was greater than the old map because LiDAR had been scanned later than the aerial photograph for the old digital map.

The average of building boundaries' differences between the different data sources was calculated as 6.73m and was larger than the admissible error range at the scale of 1/5,000, 2.5m.

5. CONCLUSION

LiDAR and currently used map showed both good performance in estimating elevation and constructing 3D topological map. LiDAR showed also good performance in estimating tree height, while the current used map has no information about the tree height. Exact and up-to-dated locations and outlines of buildings cab be easily identified and extracted with the help of LiDAR.

LiDAR can be very useful in preparing 3 D topological map, regarding estimating ground elevation, extracting outline and estimating height if land features like vegetations and buildings.

References from Journals:

Baltsavias, E.P., 1999. Airborne laser scanning: Basic relations and formulas. *ISPRS Journal of Photogrammetry and Remote Sensing*, 54, pp.199-214.

Lee, G. S., Gho, D.G., and K. S. Cho., 2003. The Evaluation of architectural density on urban district using airborne laser scanning data. *The Korean Association of Geographic Information Studies*, 6(3), pp.95~106.

Dubayah, R. O., Drake, J. B., 2000. Lidar remote sensing for forestry. *Journal of Forestry* 98(6), pp.44-46.

References from Books:

Smith, J., 1989. *Space Data from Earth Sciences.* Elsevier, Amsterdam, pp. 321-332.

References from Other Literature:

Lim, K., P. Treitz, A. Groot, and B. St-Onge., 2001. Estimation of individual tree heights using LiDAR remote sensing. *Proceedings of the Twenty-Third Annual Canadian Symposium on Remote Sensing*, Quebec, QC, August, pp.20-24.