MEASURING CROWN PROJECTION AREA AND TREE HEIGHT USING LIDAR

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ABSTRACT:

LiDAR(Light Detection and Ranging) with digital aerial photograph can be used to measure tree growth factors like total height, height of clear-length, dbh(diameter at breast height) and crown projection area. Delineating crown is an important process for identifying and numbering individual trees. Crown delineation can be done by watershed method to segment basin according to elevation values of DSMmax produced by LiDAR. Digital aerial photograph can be used to validate the crown projection area using LiDAR. And tree height can be acquired by image processing using window filter(3cell×3cell or 5cell×5cell) that compares grid elevation values of individual crown segmented by watershed.

1. Introduction

Automatic measurements with high precision of position, height, and crown diameter of individual trees have been performed using LiDAR in the forests of Europe(e.g., Hyyppa¨, Kelle, Lehikoinen, & Inkinen, 2001; Persson, Holmgren, & So¨derman, 2002; Schardt, Ziegler, Wimmer, Wack, & Hyyppa¨, 2002). High-resolution LiDAR data is typically used to automatically generate a digital canopy model that describes the outer contour of the tree crowns(Holmgren, 2004). LiDAR technique can supply forest monitoring and management planning with information of most trees(e.g., position and tree size), which earlier was impossible to achieve with the same efficiency and precision. Recent development of the Global Positioning System(GPS) and Inertial Navigation Systems(INS) now makes it possible to determine the orientation of a sensor with high precision without using any ground control points. Several types of airborne sensors, e.g., digital frame cameras, airborne laser scanners, and multi-spectral scanners, are therefore becoming more operational for identification and classification of objects on the ground(Holmgren, 2004). In This study, individual trees was detected and tree heights could be measured by DSM segmented through watershed segmentation

2. Materials and method

2.1 Study Area

A study area is upper left 127°29′0.19380″E, 37°36′16.43433″N and lower right 127°30′1.10″E, 37°35′42.94″N around Mt. Yumyeong in South Korea.

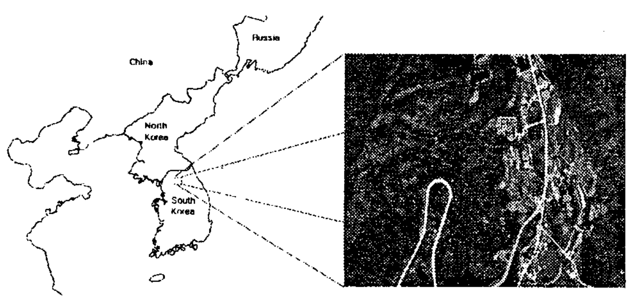

Figure 1. Study area

Test sites are 15 plots set up each 10m×10m size in *Pinus koraiensis, Larix leptolepis* and *Quercus* spp. stands. These test sites were selected due to the fact that structure of tree species is simple and individual tree location is apart from each other.

2.2 Study Materials

2.2.1 LiDAR Data and Digital Aerial Photograph

LiDAR data has 20±10 cm spatial resolution (1.8point/m²) acquired on 3,000m altitude and digital aerial photograph has 20±10 cm spatial resolution with red, green and blue band. Both LiDAR data and digital aerial photograph were obtained at April 2004.

2.2.2 Ground Data

Test sites were determined on digital aerial photograph and DSM(Digital Canopy Model) using LiDAR preferentially. Those were composed with 15plots by 100 m² per 1plot. 137 individual trees were measured with *Pinus koraiensis*(47), *Larix leptolepis*(46) and *Quercus* spp.(43) individual trees(*Quercus mongolica* and *Quercus variabilis*). Survey items were coordination of individual tree and tree height. Each position of individual trees was acquired at breast height of individual trees using GPS Pathfinder Pro XR manufactured by Trimble Company.

3. Study Method

3.1 Crown projection

Study area was selected first of all with digital aerial photograph and DSM preferentially and then crown delineation was performed using watershed segment method. Each tree height of individual trees detected was determined in the highest value of segmented crown cells. Accuracy of Estimated tree height and number of individual trees were validated with field data.

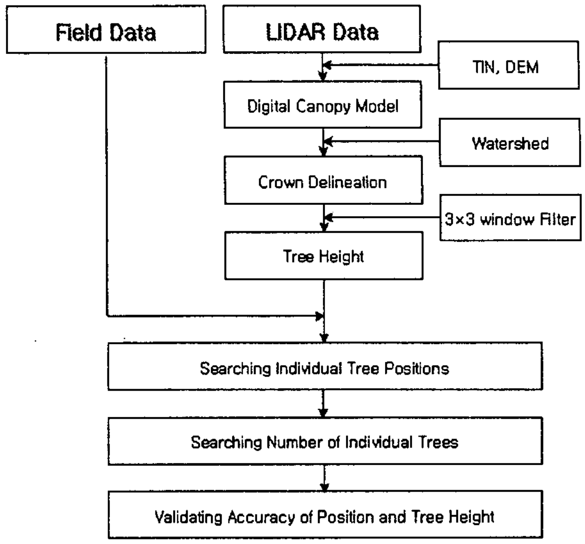

Figure 2. Estimation of crown projection and tree height

3.2 Classification of tree species using digital aerial photograph

Digital aerial photograph was used to classify species and validate accuracy by species. It was segmented by Region Growing Method that was to define heterogeneity of image object and then last segment imagery was classified using Maximum likelihood method.

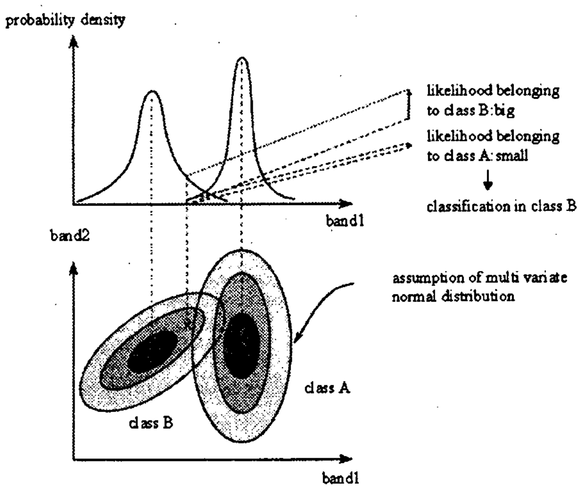

Figure 3. Concept of Maximum likelihood Method

4. Result

4.1 Crown delineation and individual tree detection

Crown projection achieved by watershed segment method was done by test sites.

Figure 4. Example of crown projection by watershed segment method

Besides, Crowns segmented in sample sites can express number of individual trees. Error range was -1 ~ +3 and number of individual trees was detected to show 0.8 tree increase a plot on an average. Individual trees of *Pinus densiflora* was distributed from -1 to +2 in sample site segmented by watershed method. As range of *Larix leptolepis* was -1 ~ +3, width of variation was the largest of three species. Because distribution of *Quercus* spp. was estimated at -1 ~ +1, variation was the smallest of three species.

Table 1. Detection of individual trees by species

Species	plot	Number of Individual trees(N)		
		observed	predicted	difference
Pinus Koraiensis	1	9	11	+2
	2	11	13	+2
	3	11	10	-1
	4	8	7	-1
	5	8	9	+1
Larix leptolepis	6	10	13	+3
	7	8	11	+3
	8	10	12	+2
	9	9	10	+1
	10	8	7	-1
Quercus spp.	11	8	7	-1
	12	10	11	+1
	13	9	8	-1
	14	9	10	+1
	15	7	8	+1

4.2 Classification of tree species using digital aerial photograph

Accuracy of Classification was estimated significantly at 0.7688. After computing occupied area by species using classified imagery, tree heights were estimated by three species.

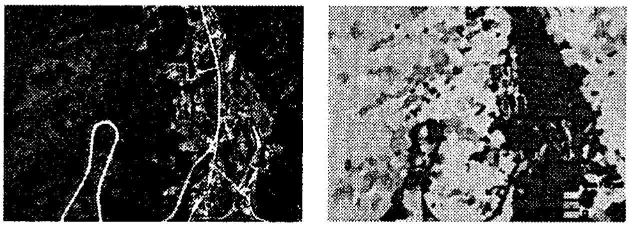

Figure 5. Segment Based classification of digital aerial photograph

Table 6. Error matrix of segment based classification

Classified Data	PK	PL	Q	Non Forest	Row Total	User's Accuracy
PK	8	1	1	0	10	0.8000
PL	3	7	0	0	10	0.7000
Q	0	0	9	1	10	0.9000
Non Forest	10	1	2	27	40	0.6750
Column Total	21	9	12	28	70	-
Producer's Accuracy	0.3810	0.777	0.7500	0.964	-	0.7688

4.3 Estimation of tree heights

Tree heights were estimated in polygons segmented by watershed segment method. Tree heights were determined by the highest elevation value of DSM gird.

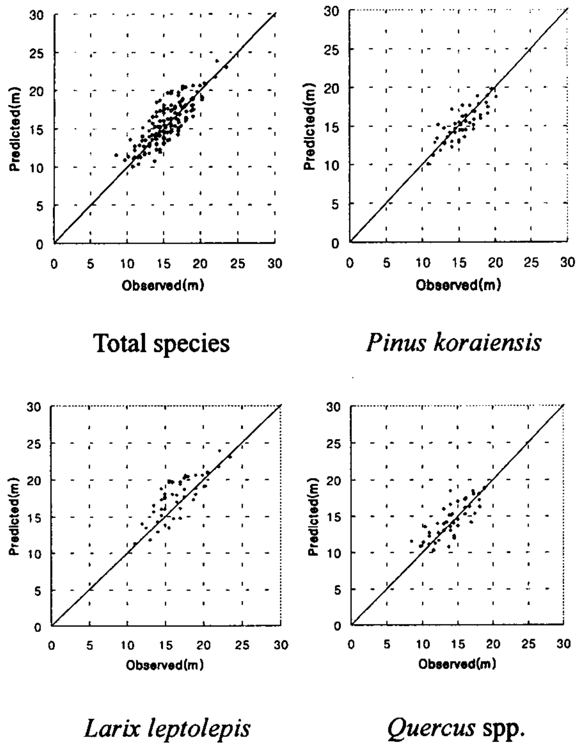

Figure 6. Accuracy of tree heights by species

Coefficient of determination of tree height about total species was 0.66. *Pinus koraiensis* was estimated at 0.68, *Larix leptolepis* at 0.68 and *Quercus* spp. at 0.60.

5. Discussion and conclusions

In this study, both projecting crown and numbering individual trees could be detected at the same time. But when crown projection by watershed segment method had some error that detected individual trees were more or less than surveyed them. These problems can be solved in the method to remove gap after searching that in the forest area or model crown projection by environmental and morphological characteristics.

6. References

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