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Use of Crown Feature Analysis to Separate the Two Pine Species in QuickBird Imagery

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Abstract : Tree species-specific estimates with spaceborne high-resolution imagery improve estimation of forest biomass which is needed to predict the long term planning for the sustainable forest management(SFM). This paper is a contribution to develop crown distinguishing coniferous species, Pinus densiflora and Pinus koraiensis, from QuickBird imagery. The proposed feature analysis derived from shape parameters and first and second-order statistical texture features of the same test area were compared for the two species separation and delineation. As expected, initial studies have shown that both formfactor and compactness shape parameters provided the successful differentiating method between the pine species within the compartment for single crown identification from spaceborne high resolution imagery. Another result revealed that the selected texture parameters - the mean, variance, angular second moment(ASM) - in the infrared band image could produce good subset combination of texture features for representing detailed tree crown outline.

Key Words : Formfactor, Compactness, Feature extraction, Feature analysis, Crown shape measurement.

1. Introduction

Tree crown measurements with high-resolution satellite images are an important factor in the precision forest inventory. Increasingly, the inventory data are used to estimate forest resources over large areas. Moreover, the estimated values can be assessed for practices of the sustainable forest management in accordance with the criteria and indicators determined by the Ministerial Conference on the Protection of in Europe (MCPFE, 1990) and the Montréal Process (Montréal Conference working Group, 2005).

In the above view, recent study has been focused in the single tree-based canopy extraction and species classification for the accurate estimation (Kayirakire *et al.*, 2006; Van Coillie *et al.*, 2007; Larsen, 2007). Even with semi-automates individual tree crown delineation performance, not all species identification can be achieves using spaceborne high-resolution images.

The aforementioned limitations were caused by the following conditions:

(1) poor spatial resolutions of the sensors(allowed

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pixel sizes < 0.6m GSD according to Leckie *et al.*, 2003)

(2) weak spectral resolution due to the infernal variability in sunlit and shaded crown

(3) complex canopy structure among broader dominant, co-dominant, and small trees

To improve the discrimination capability of single tree species, this work aims toward the development of available techniques to separate two pine species into Korean Pine (P. koraiensis) and Japanese Red Pine (P. densiflora) at Kwangneung Experiment Forest, Korea by using QuickBird imagery.

Under the consideration that crown boundaries can be well detected at visual recognition, texture features extraction before the shape feature analysis was also proposed as an image enhancement approach for crown outlines.

2. Study Area and Data

The study site is situated in 1111ha Kwangneung Experiment Forest, 127°12′ 05″ North in latitude and 37°70′ 50″ - 37°81′ 32″ East in longitude, which is located of 39km east of Seoul. Vegetation of the stands characterized by brown forest soil and temperate climate, is composed of coniferous, deciduous, and mixed forests. Where compartment no.19 was selected for the texture features extraction, compartment no.8 and no.51 were chosen as crown shape-specific measurements for Korean Pine and Japanese Red Pine, respectively. The QuickBird image data for the area were obtained at 11: 21 AM on 5 April 2005, with a solar elevation of 54.4° and a sun azimuth of 147.8°. The QuickBird multi-spectral bands (Blue: 450-520nm, Green: 520-600nm, Red: 630-690nm, NIR: 760-900nm) with spatial resolution of 2.4m are not applicable to the observation of an individual tree. Therefore, the QB multi-spectral data

Table 1. Band specifications of QuickBird Sensor. *Data collected at 11-bit resolution is delivered in either 8-or 16-bit format

Band	Resolution			
	Spectral (μm)	Spatial (m)	*Radiometric (bits)	Temporal (days)
Blue	0.45-0.52	2.44	11	11
Green	0.52-0.60	2.44	11	11
Red	0.60-0.69	2.44	11	11
NIR	0.76-0.90	2.44	11	11
Pan	0.45-0.90	0.61	11	11

were fused with the 0.6m panchromatic band (450-900nm) using a pan-sharpening algorithm to make the pan-sharpening MS image data with 0.71m ground sample distance(GSD). Table 1 shows other resolutions of QuickBird sensor.

3. Methodology

Tree crown visual interpretation and measurements with spaceborne image data have remained more difficult than on aerial photographs since trees show more structural detail at higher resolutions. In practice, the spatial resolution of QuickBird mentioned in Section 1 is founded to be insufficient for distinguishing individual tree species between Korean Pine and Japanese Red Pine. Thus, given the satellite data with poor isolation id individual trees, appropriate feature analysis techniques, namely the measured parameters for extracted features are required to divide the two pine species.

1) Canopy Texture Features

Although texture features have rarely been used for estimation of forest parameters (Kayitakire *et al.*, 2006), the texture parameters used in the analysis of canopy transition zone consist of homogeneity, dissimilarity, entropy, and angular second moment (ASM). Homogeneity and dissimilarity in the image

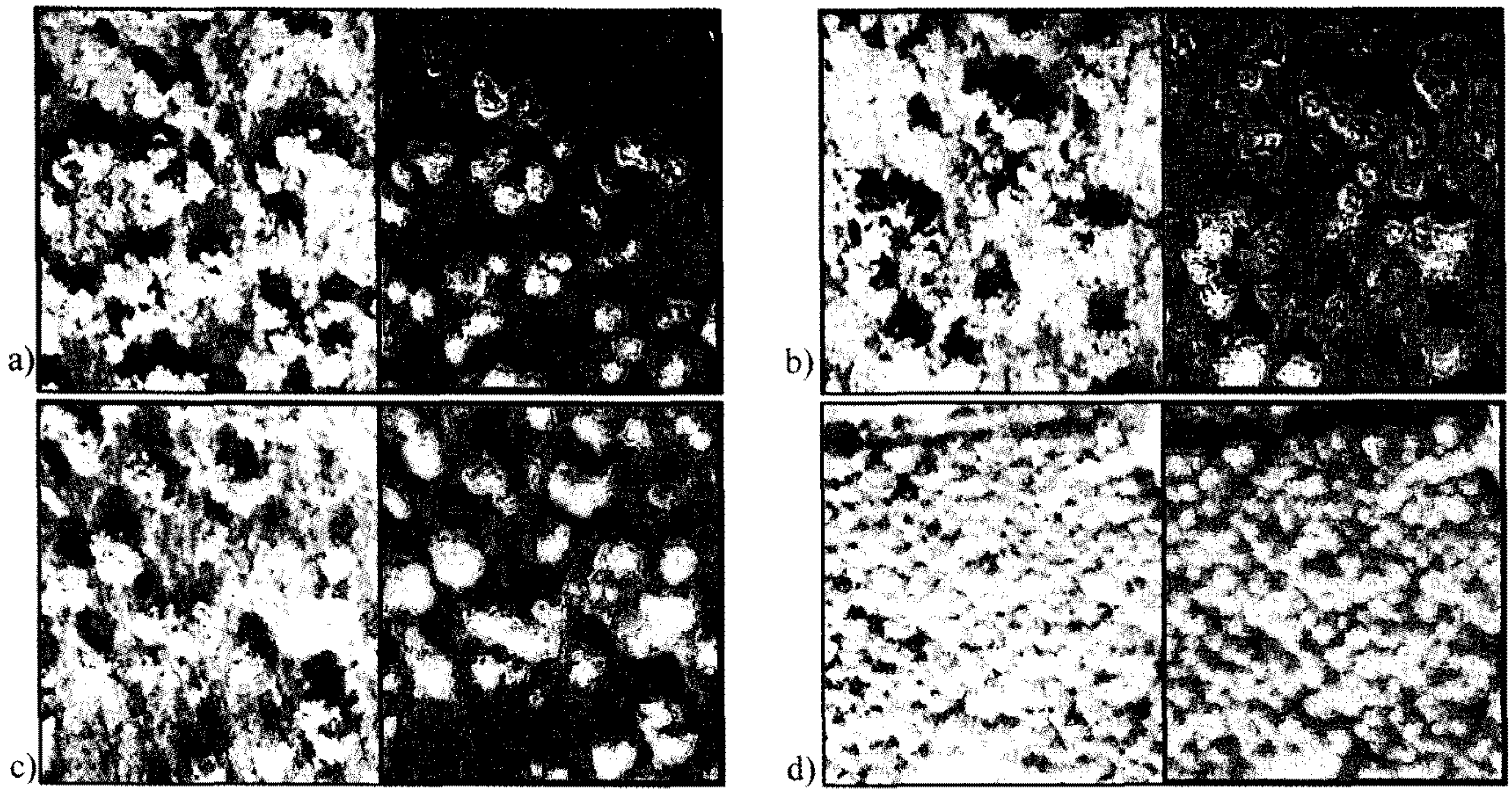


Fig. 1. Textural features of compartment no.19, Kwangneung Experiment Forest detected by using three parameters with 3 by 3 window. (a) Japanese Red Pine (left image: color composite, right image: texture feature). (b) Korean Pine. (c) Mixed tree of Japanese Red Pine and Korean Pine. (d) Korean Pine trees of 5age class.

are adjusted with Grey Level Co-occurrence Matrix (GLCM) be generated from which the texture features are derived, as proposed by Haralick *et al.* (1973). And Neighboring Grey Level Dependence Matrix (NGLDM) texture feature produce measures of image second moment and image entropy (sun and Wee, 1983; Pearlstine *et al.*, 2005). Texture features calculated from homogeneity, dissimilarity, entropy and ASM in QuickBird infrared image are not illustrated here, shown in references (Kim and Hong, 2007). Theses four features were used to generated the co-occurrence matrix, which are applied at texture classification for forest structure. In this paper, three texture measures- mean, variance, and ASM in the infrared image were selected for identification of individual pine species, are adjustable texture operators as the multiple texture features shown in Fig. 1.

2) Crown Shape Parameters

To prove the single tree discrimination, three distinctive parameters were used to measure the sizes of the identified crown in the image.

First, formfactor that varies with surface irregularities is given by

$$F = \frac{4\pi \cdot Area}{Perimeter^2}$$

Compactness is also used to determine the irregularity of crown boundaries as the inverse metric of the thinness, and is given by

$$C = \frac{\sqrt{(4/\pi) \cdot Area}}{MaximumDiameter}$$

Finally, aspect ratio (also called eccentricity) defined by the ratio of an oriented bounding box (OBB) due to not rotationally invariant, is expressed as

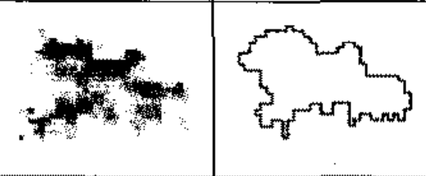
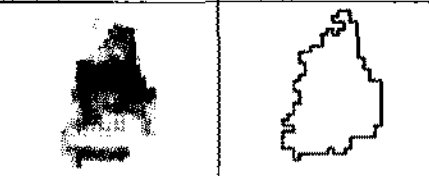
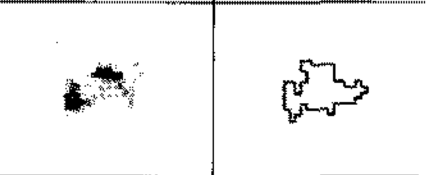
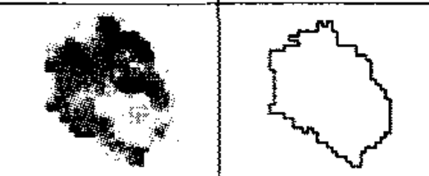
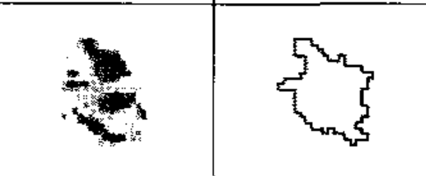
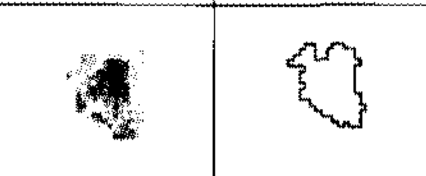
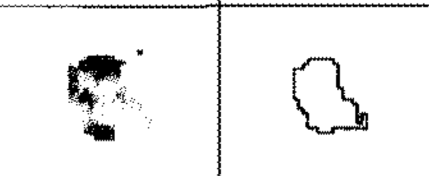
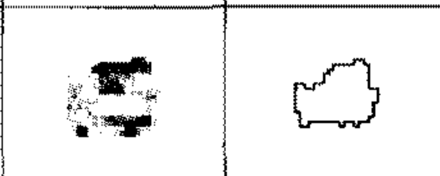
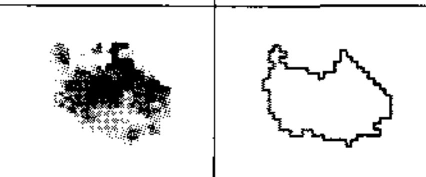
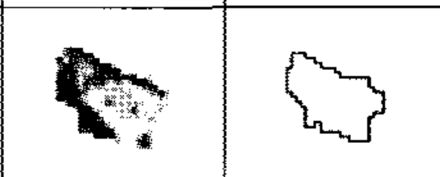
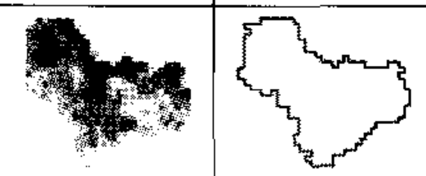
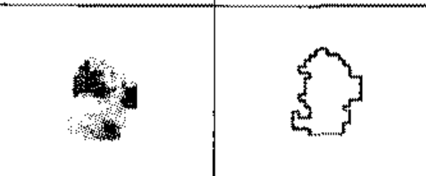
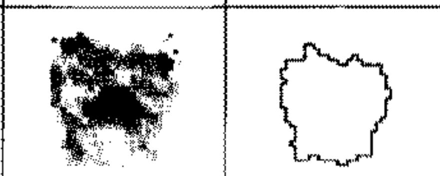
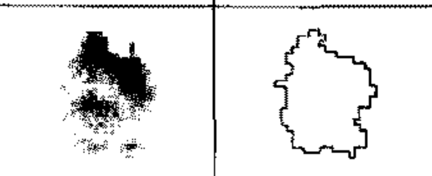
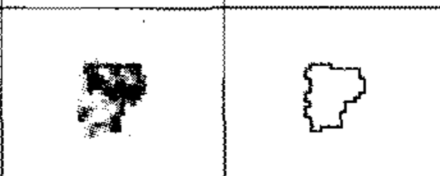
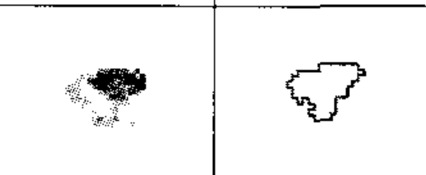
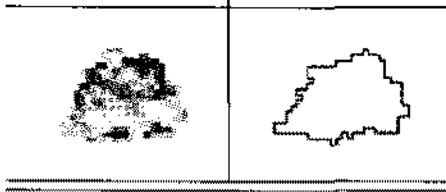
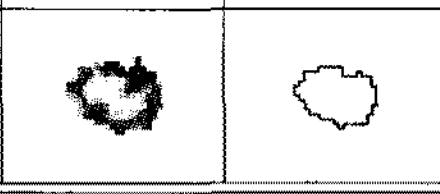
$$AR = \frac{MaximumDiameter}{MinimumDiameter}$$

Formulas for calculating formfactor, compactness, and aspect ratio are referred to Russ (2002).

Such the extracted shape feature measurements were performed by using the IDL written program.

Because the specific measure algorithms have not been implemented for commercial software, the

Table 2. Variations of the three shapes-related numeric values on one selected crown feature for each 12 single trees between the two pine species

Japanese Red Pine(P.densiflora)					Korean Pine(P.koraiensis)				
Selected Features		Values			Selected Features		Values		
Original	Outline	Formfactor	Aspect ratio	Compactness	Original	Outline	Formfactor	Aspect ratio	Compactness
		0.229	1.773	0.152			0.325	1.727	0.181
		0.252	1.312	0.160			0.353	1.101	0.189
		0.274	1.287	0.167			0.403	1.443	0.202
		0.285	1.419	0.170			0.405	1.185	0.203
		0.305	1.410	0.176			0.426	1.614	0.208
		0.310	1.329	0.177			0.446	1.474	0.213
		0.313	1.517	0.178			0.446	1.745	0.213
		0.314	1.502	0.178			0.450	1.292	0.214
		0.340	1.522	0.186			0.461	1.077	0.216
		0.370	1.333	0.194			0.465	1.610	0.217
		0.376	1.197	0.195			0.475	1.776	0.219
		0.377	1.615	0.195			0.500	1.391	0.225

detailed computation steps are omitted in this paper.

The projected crown shapes and textural features can be used as the objected primitives for image classification, because a feature in two-dimensional image corresponds to an object in three-dimensional space. Thus, crown shape parameters used for the identification of pine species in QuickBird image can be adapted for objected-oriented classifications by using high resolution imagery.

4. Results and Discussion

Fig. 1. demonstrates that the three texture feature IR images derives from the three texture operators (i.e., parameters) with the window (i.e., kernel) size 3

by 3 pixels describe best automated single tree crown detected and delineation between age classes of pine species in the mixed forest cover.

Because of the variations of crown boundary involved, namely within-feature spectral variation, texture parameters did not measure proper crown size of tree species, so that the tree canopies with similar spectral properties could not isolate between the tree species (crowns). This fact could be the case according to the research of Tuominen & Pekkarinen (2005) because it is difficult to successfully the recognition of objects (in the case of trees) solely based on quantified texture features.

To ensure successful single tree species classification 12 crown samples for each individual pines (Korean Pine and Japanese Red Pine) were selected in the compartment no.8 and the compartment no.51, respectively.

Table 1 show the comparisons between the pine species for the values of three shape parameters based on each 12 individual crown feature samples. It can be notes that formfactor values of Korean Pine are higher than those of Japanese Red Pine. In addition, the Korean Pine values measures by compactness parameter are also higher in comparison to the Japanese Red Pine. Theses results confirm that Korean Pine has more irregularity to crown boundary than Japanese Red Pine in general, although the mean difference of aspect ratio between the two pine species is less than 2 numeric values in Table 2. There is not much difference of the aspect ratio related variations on the area, but the formfactor and the compactness are not unique relative to the area(size). Table 2 indicates that three shape parameters were assessed using a paired-t test on each the twelve extracted crown features. As can be seen from the results, both formfactor and compactness shape descriptor provided significant discrimination between the two pine species. On the other hand, the rejected aspect ratio parameter was not adequate to identify pine species, because the significance for aspect ratio is less than the level of significance of the t-test (if $\alpha = 0.05$, then $F = 2.20$). Therefore, both formfactor and compactness shape parameters which were used for single pine species identification in this work, produced acceptable discrimination between Korean Pine and Japanese Red Pine.

Table 3. T-test evaluation of the twelve extracted crown features between two pine species for three shape parameters

		P.koraiensis	P.densiflora
Formfactor	mean	0.429	0.312
	variance	0.002	0.002
	t-statistic	5.438	
Aspect ratio	mean	1.452	1.434
	variance	0.062	0.025
	t-statistic	0.254	
Compactness	mean	0.208	0.1773
	variance	0.000	0.000
	t-statistic	5.317	

5. Conclusion

A feature extraction and a feature analysis method for single tree species identification using high-resolution imagery is proposed and discussed. As can be seen from the results in this study, the formfactor and compactness measurements that were performed on each of individual extracted crowns in QuickBird image, will be useful for single tree species identifications and classifications by using high-resolution images. Further, three texture measures based on mean, variance and ASM were performed to detect single tree canopy with QuickBird image, can be also used for single tree delineation by using satellite high-resolution imagery. Both methods developed are applied to analyzing object-oriented classifications in the multi-spectral images.

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