Analysis of Texture Information with High Resolution Imagery for Characterizing Forest Stand

T. G. KIM* and K. S. LEE
Inha University, Department of Geoinformatic Engineering
253 Yonghyun-dong Nam-gu, Incheon 401-751, Korea
g2021540@inhavision.inha.ac.kr

Abstract: Although there have been wide range of studies to characterize forest stands based upon spectral information of satellite image, it was not fully understood the texture information of forest stand using high resolution data. The objective of this study is to evaluate several texture measures for characterizing forest stand structure, such as species composition, diameter at breast height(DBH), stand density, and age. High resolution IKONOS satellite imagery data were acquired in August 2001 over the forested area near Ulsan, Korea. Primary forest types were plantation pine, mixed forest, and natural deciduous forest of stand age ranging from 10 to 50 years old. Several GLCM-based texture measures were compared with forest stand characteristics. In overall, a texture measure (contrast) calculated using red band were better to differentiate species and age group than other texture measures and near infrared bands.

Keywords: Texture measure, GLCM, IKONOS, forest

1. Introduction

With increasing availability of new high spatial resolution imagery from satellite platforms, these image data (such as IKONOS) provide opportunity to identify ground features that was not previously available using medium resolution imagery [1]. Additionally, texture features (along with spectral feature) available with the high resolution imagery can better describe the forest stand characteristics [3]. To effectively analyze texture information on forest stand property such as species composition and age-class, a few studies have adopted several texture measures calculated from the gray level co-occurrence matrix (GLCM). Image texture difference between age class of forest stand can be variously described by the moving window size over which texture measure is derived [3]. In classification of forest species composition, the additional texture information improved classification accuracy [2][4].

Although texture information can help to interpret forest stand characteristics, it has not been fully understood that which texture measure is more effective to describe which forest stand property. Texture image can be generated according to various combinations of spectral band and moving window size. The objective of this study is to evaluate the effectiveness of various texture measures obtained from the high resolution satellite data for assessing forest characteristics.

2. Methods

1) Study site and data used

The study area is located near Ulsan city in southern part of the Korean peninsula. Dominant forest types are mixed deciduous and coniferous, plantation pine and larch, and natural deciduous stands. Forest stand age ranges from 10 to 50 year.

The pan-sharpened multispectral IKONOS imagery was acquired on October 23, 2001. Using forest stand maps produced by the Korea Forest Research Institute in 2000, 41 sample forest stands of known stand characteristics were selected (Figure 1). The forest stand maps were made by interpreting 1:15,000 scale black and white aerial photos and field survey and showed detailed stand characteristics of species group and age and DBH class.

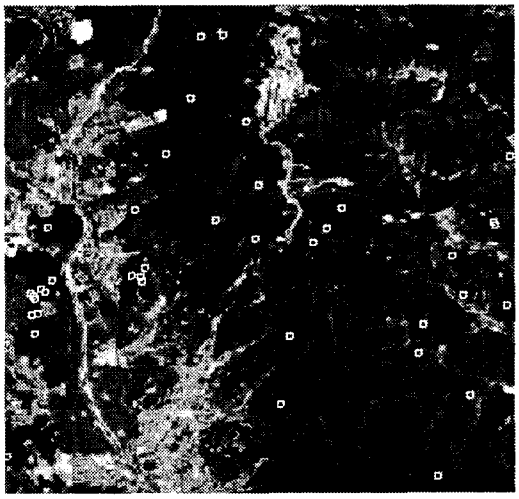

Fig 1. Color composite imagery over the study area and 41 sample forest stands of known stand property.

2) Generation of texture image

To evaluate the relationship between texture measure and forest stand characteristics, several texture images were produced from the geo-referenced IKONOS data. Three different texture measures were derived using GLCM that that is two dimensional array to show the spatial relationship between one pixel and its neighboring pixel [5]. Calculation of three texture measures, con-

trast(CON), angular second moment (ASM), correlation (COR), are calculated as follows:

$$CON = \sum_{i=1}^{n}\sum_{l=1}^{m} P(i,j)\{R(i)-C(j)\}^2$$

$$ASM = \sum_{i=1}^{n}\sum_{l=1}^{m} P(i,j)^2$$

$$COR = \frac{\sum_{i=1}^{n}\sum_{l=1}^{m} P(i,j)[R(i)-Mean\_R(i)][C(j)-Mean\_C(j)]}{\sum_{i=1}^{n}\sum_{l=1}^{m} P(i,j)\{R(i)-C(j)\}^2}$$

Where P(i,j) = the spatial co-occurrence matrix element,
R(i) = the grey level value for the row,
C(j) = the grey-level value for the column.

To evaluate the variability of texture measures according to the spectral band used and moving window size, we used two spectral bands of a visible (red) and a near infrared (NIR) spectrum and three window-size (5x5, 25x25, 51x51). Total 18 texture images were produced according to the combination of input band, window size and three texture measures. The vector file of 41 sample plot boundary were then overlaid to the 18 texture images and pixels within the boundary were extracted. The mean texture value within a plot (30m in diameter) represents the texture value for the stand.

3. Results and Discussions

As a preliminary approach, two stand characteristics (species group and age class) were compared with various texture measures. There are six species group (natural pine, mixed coniferous and deciduous, mixed deciduous, plantation Korean pine, plantation larch and plantation pitch pine). Although total range of stand age in the study area is between 10 to 50 years old, most stands are age class 2 and 3 (10 to 30 years old). Only natural pine stands has additional age class 4. To exclude any combined effect between stand characteristics, we tried to focus an individual stand parameter at one time.

Among those 41 sample stands, only 17 stands shares approximately the same stand age, density, and DBH. About 3 sample plots are represented for each of six species groups. Figure 2 shows that the mean texture value of six species group for each of 18 texture measures. In overall, the separation among the six species groups is better seen with contrast texture measure. In contrast texture measure, two deciduous groups are different from other coniferous groups in near infrared bands, which seems to be normal considering the spectral reflectance between two major species group. However, the difference among four coniferous groups was not distinct. In overall, the best separation among those

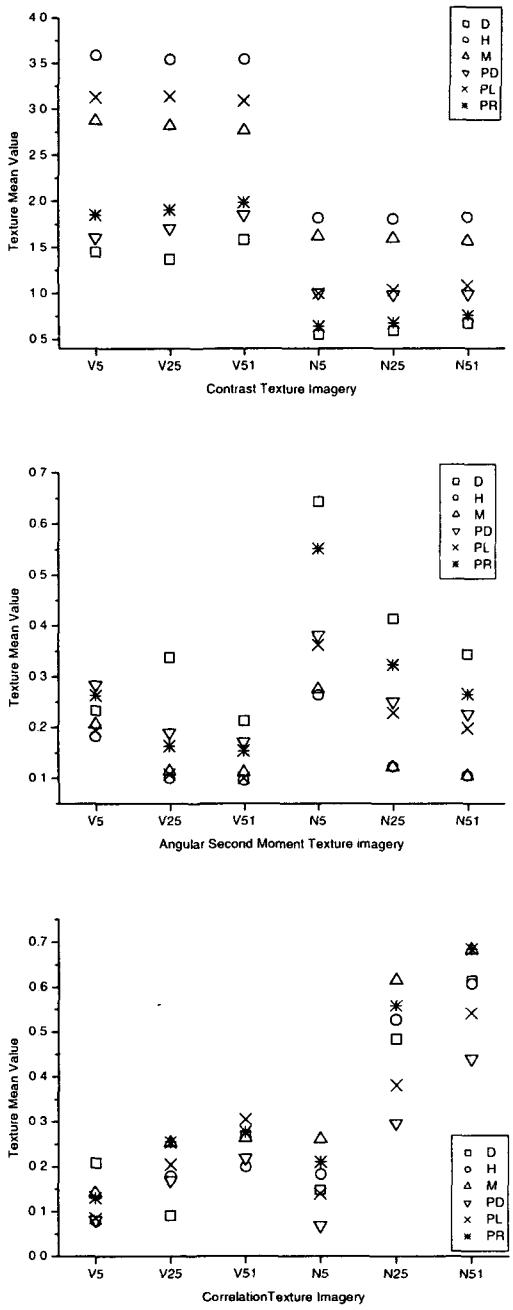

Fig 2. Mean texture value of six species group from the 18 texture image (D: natural pine, H: broadleaf forest, M: Mixed deciduous and confiers, PD: plantation Korean pine, PL: plantation larch, PR : plantation pitch pine). Texture measure from various combination are noted by V(red band), N(NIR band), and window size (5, 25, 51).

six species groups were found in the contrast texture measure with visible band and 25 window size although the effect of window size did not look significant. In angular second moment texture image, the distinction between broadleaf and other groups is noticeable with near infrared band. In correlation texture image, no significant pattern of texture difference among species groups are showed, except for the combination with NIR

ban and 25 window size. Comparing three texture measures, the contrast looks more effective than the other two texture measures to discriminate six species group.

Figure 3 shows the mean texture values of three age classes of natural pine stands. In the contrast texture imagery, the difference of mean texture mean value from visible band is higher than the ones from near infrared band. The mean texture values from ASM (angular second moment) texture image indicated that the difference of texture value slightly increases as the window size increases with near infrared band. Age class 4 is better separated from the two other age classes in CON and ASM. In the correlation texture image, there is no clear pattern to distinguish three age classes.

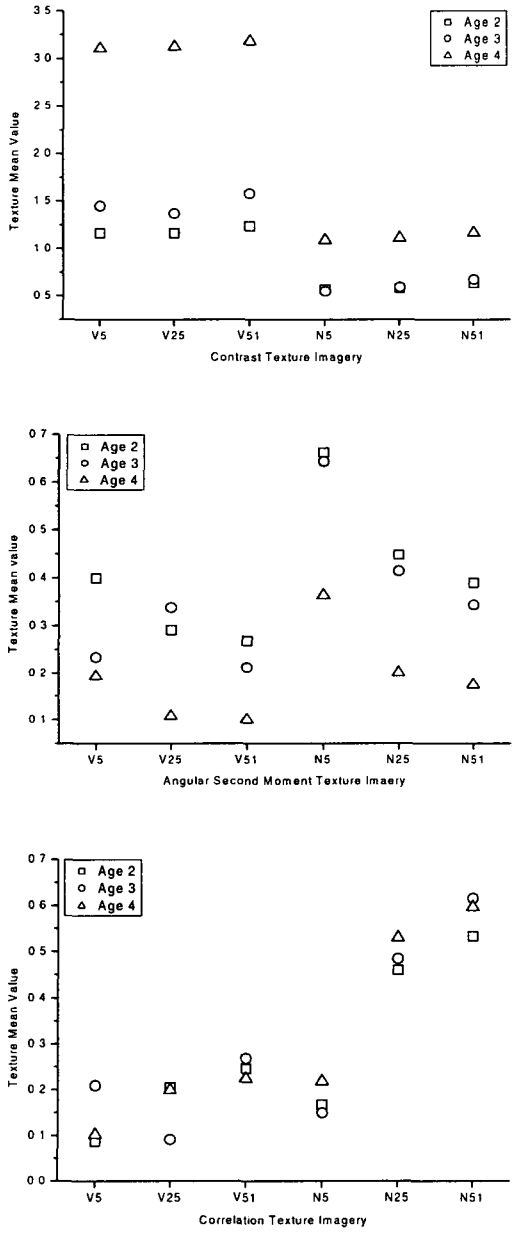

Fig 3. Mean texture value of three age classes of natural pine forest (D) extracted from the 18 texture image (Age 2: 11-20 year, Age 3: 21-30 year, Age 4: 31-40 year).

From this preliminary analysis, the CON texture measure with visible band appears more effective to distinguish both species group and age class. The effect of window size was not very clear to obtain the optimal texture measure for characterizing forest stand although there are a few cases where window size may have influence.

4. Conclusions

Texture information would be additional benefit for the characterization of forest stand structure, which is often difficult from traditional spectral information only. Although texture information may help to interpret forest stand characteristics, it has not been fully understood that which texture measure is more effective to describe certain forest stand property. Combinations of spectral band and moving window size can derive various texture information even for a single texture measure.

The results obtained from this preliminary analysis on the various texture measures shows the effect of spectral band used to derive texture measure for characterizing forest stand. The contrast texture obtained from visible band was more effective for distinguishing species groups and age class. The texture features derived from high resolution imagery can be used to increase the capability of the satellite remote sensor data for characterizing forest stand structure. Further studies on other stand characteristics, such as density, height, and DBH, are planned.

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