Detection of the Damaged Trees by Pine Wilt Disease Using IKONOS Image

S. H. Lee, H. K. Cho, J. B. Kim
Korea Forest Research Institute
207 Chongnyangni-dong, Dongdaemun-ku, Seoul , Korea
frishlee@foa.go.kr, h.k.cho@krpost.net, jbkim99@goa.go.kr

M. H. Jo
Department of Urban Information Engineering, Kyungil University
33 Buho-ri, Hayang-up, Kyungsan-si, Kyungsang bukdo, 712-701, Korea
mhjo@bear.kyungil.ac.kr

Abstract: The purpose of this study is to detect the damaged red pine trees by pine wilt disease using high resolution satellite image of IKONOS Geo. IKONOS images are segmented with eCognition image processing software. A segment based maximum likelihood classification was performed to delineate the pine stand. The pine stands are regarded as a potential damage area. In order to develop a methodology to detect the location of damaged trees from the high resolution satellite image, black and white aerial photographs were used as a simulated image. The developed method based on filtering technique. A local maximum filter was adapted to detect the location of individual tree. This report presents a part of the first year results of an ongoing project.

Keywords: pine wilt disease, IKONOS, segment based classification, local maximum filter.

1. Introduction

Red pine (*Pinus densiflora S. et Z.)* is the most favorite tree species in Korea (Bae, 2003). Pine forest covers ca. 30% of whole forest area in this country, but nowadays it becomes smaller and smaller. One of the main causes influencing the decrease of pine forest is the disease and insect attack. In recent years pine wilt disease broke out and rapidly spread over in the southern part of Korean peninsula. It is a serious threat to forestry and is called as "AIDS of Pine", because all of the affected trees will be blight to death within few months. To prevent the pine wilt disease from spreading in time it is very important to find the damage front as possible as in early stage.

Remote sensing data is often regarded as a useful information source for such purposes. However, the use of space-borne remote sensing data has been hindered by the relatively coarse spatial resolution. Up to now, forest managers have paid a little attention to the satellite data and still used aerial photographs solely and field survey. The new generation of high resolution satellite sensors like IKONOS could overcome this matter, since the spatial resolutions are comparable with those of aerial photographs. Moreover it is also expected that the planned KOMPSAT-2 MSC data will contribute to enhance the application of high resolution satellite images.

This study was carried out to detect the pine trees attacked by pine wilt disease and its front area using high resolution satellite images.

2. Pine Wilt Disease

The cause of pine wilt disease is infestation of pinewood nematode (*Bursaphelenchus xylopilus*). The nematode is blocking the tracheid of plant metabolism, which leads the pine tree blight to death. The pinewood nematode is not able to migrate from tree to tree on its own. The main vector insect is the sawyer beetle (*Monochamus alternatus*). The beetle is infected by the pine wood nematode while it transforms from the pupa to the adult. Young pine wood nematodes find their way into the spiracles of the adult. The beetle emerges and flies to the crown of a healthy tree for sufficient feeding on the new shoots of young branches. While the beetles are feeding, the nematodes enter the wounds of the tree and infest in vascular tissues and the sapwood.

Figure 1. The Pinewood nematode (*Bursaphelenchus xylopilus*), sawyer beetle (*Monochamus alternatus*) and damaged trees by Pine Wilt Disease (from left to right).

This disease attacks individual trees, not the whole stand instead. Once a pine tree is damaged, tree cutting follows as soon as possible to prevent the disease from spreading to neighboring trees. Therefore date of imaging is very important to detect the damaged trees using satellite images.

3. Study Area and Materials

The study area is located at Daebyun-ri, Gijang-gun, Busan metropolitan city, Korea. Daebyun-ri is one of the front area damaged by pine wilt disease since 1998.

Considering the life cycle of sawyer beetle and control activities, November and/or December is assumed to be the best time to obtain an image for this purpose.

Black & white aerial photographs taken in November 2002 at the scale of 1:6,000 were used to develop a de-

tection method for damaged trees by pine wilt disease. The aerial photographs were digitized at a pixel size of 21 μm with EPSON GT-12000 desktop scanner. It corresponds to 12.6 cm at ground.

A pan-sharpened IKONOS Geo image obtained on January 13, 2003 was used as a high resolution image. The IKONOS image has 4 spectral bands and 1 m spatial resolution.

The positions of damaged and felled trees were measured using Trimble Pro-XR GPS equipment. Then post differential correction for the GPS measurements was processed using the base station files and DGPS data were used as reference data for satellite image analysis. In addition to the GPS measurement some attribute information such as damage status of trees and cutting date, if possible, were also recorded. Figure 2 shows the result of GPS measurements sorted by cutting date and damage level.

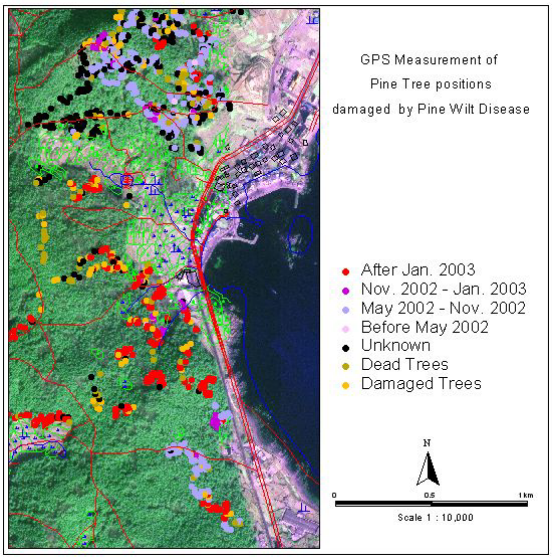

Figure 2. GPS measurements of damaged trees sorted by damage level and cutting date.

4. Image segmentation and classification

In comparison of classical approaches for analyzing low- or medium spatial resolution data obtained from Landsat TM or SPOT HRV, high spatial resolution data have a range of particularities.

Firstly, as the spatial resolution is increasing, the internal radiometric variability within meaningful objects for land cover mapping will be increased (Aplin *et al*., 1999). At a spatial resolution of 1 m, the per-pixel classification of forest land cannot be conducted without taking account of the spatial context information. The radiometric value of an isolated pixel provides little information, since the objects of interest are much larger than the pixel size. A region based classification approach is therefore required. This approach assumes that object boundaries are known. The boundaries can be derived from image segmentation results (Cho *et al.*, 2003), from manual digitizing or from an existing GIS (Smith and Fuller, 2001, Aplin *et al*., 1999).

Secondly, one must pay particular attention to texture information of high spatial resolution image. At a spatial resolution of about 1 m or less, texture analysis becomes as important as spectral analysis. Franklin *et al.* (2001) showed that higher accuracy was obtained using texture data alone than using spectral data alone when classifying forest stands in CASI imagery of a spatial resolution of about 1 m.

Under consideration of the characteristics of high spatial resolution data, segment based maximum likelihood classification was performed to delineate the pine stand (Cho *et al.* 2003). Segmentation is defined as a process of partitioning an image space into some non-overlapping meaningful homogeneous regions. The term 'meaningful' is dependent on problem. In this study eCognition image processing software was used for segmentation of IKONOS image. Segmentation algorithms adapted in eCognition is a bottom up region-merging technique starting with one-pixel. In numerous subsequent steps, smaller image objects are merged into bigger ones (Definiens-Imaging, 2003).

If the segmentation process is performed, then one can be classified the image based on segment. In this approach the smallest unit of classification is not an individual pixel in an image but the segment. Therefore, A segment based maximum likelihood classification method was used in this study. For the classification new segment specific variables were derived. We used the spectral mean values and standard deviation in each segment. The standard deviation can be regarded as a texture measure. Figure 3 shows the result of segmentation and classification.

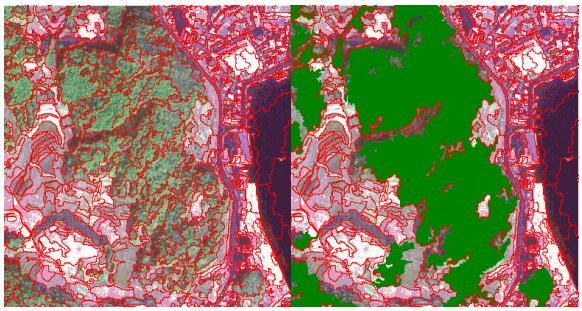

Figure 3. Result of segmentation (left image) and classification (right image). In the classified image the boundary of each segment is exported as a vector layer and only the pine stands are displayed.

5. Detection of damaged trees

Individual trees may be detected on high spatial resolution imagery as regions of high reflectance. At present, detection and delineation algorithms are based on two distinct spectral properties of tree crowns; 1) the association of a tree apex with a local maximum image brightness value, and 2) delineation of the crown boundary by local minimum brightness values. Visually, this spectral

crown structure is analogous to that of an upward pointing cone or mountainous shape when viewed in three dimensions (Fig. 4). To detect the tree apex a local maximum (LMax) filter with 10 pixels in radius was adapted. The radius with 10 pixels corresponding to ca. 2.5 m in diameter was selected, because the mean crown diameter of the pine trees was 3m approximately. The difference of 0.5 m is regarded as shadow between crowns.

In LMax filtering, a moving window was passed over all pixels in an image to determine the tree location, if a given pixel had a higher reflectance than all the others within the window. Pixels identified as the highest digital number within the window were noted as tree locations.

As the damaged trees appeared brighter than undamaged trees in black & white aerial photographs, threshold value was used to separate the damaged trees from undamaged trees.

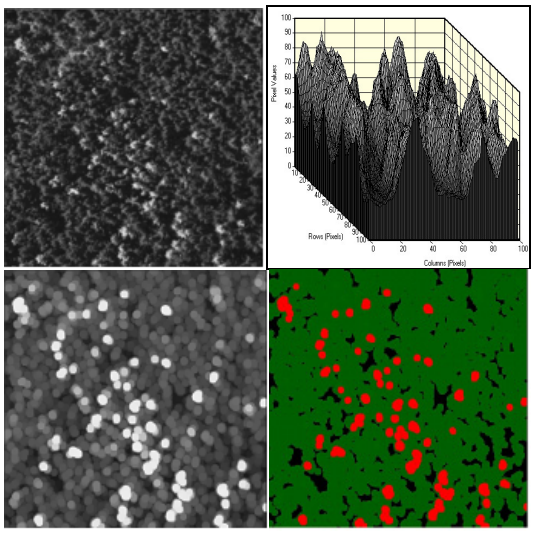

Figure 4. The figure shows the original photo (upper left), crown profile of pine stand (upper right), the result of local maximum filtering (lower left) and damaged trees detected by threshold (lower right).

The same method was applied to high resolution satellite image of IKONOS. Since the IKONOS image had 1 m spatial resolution, the window size was changed to 3 pixels. Also a focal mean filter was put into operation to eliminate unusual pixel values in the image.

Figure 5 shows the results of application. The spectral profile indicates that only the band 4 can separate the damaged (red) and undamaged (green) trees. The other bands may not distinguish the differences. Therefore band 4 was used for threshold operation. But the results showed that it was difficult to separate the damaged and undamaged trees.

The cause of such a result perhaps depended largely on mixed pixels among the tree crowns. The 1 m spatial resolution of IKONOS image is perhaps too coarse to separate the tree crown in a dense forest with relative small crown in this site.

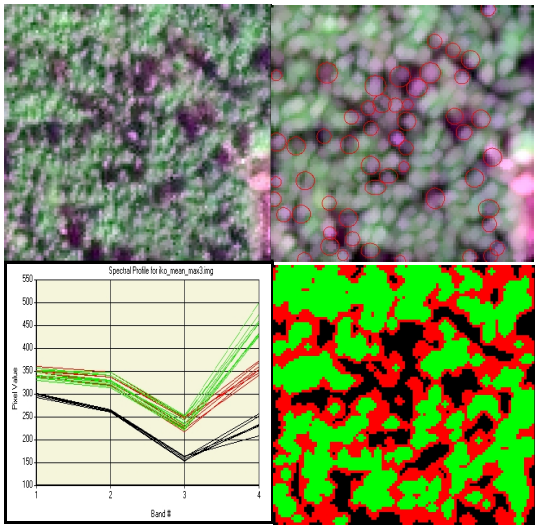

Figure 5. In the original image (upper left) the damaged trees were recognized more or less. The result of local maximum filtering operation (upper right) and the spectral profile for damaged and undamaged trees (lower left) indicated the possibility of separation. But by means of threshold operation in band 4 it was not possible. See text for details.

The pan-sharpened DRA(dynamic range adjust) applied image by Space-Imaging was used in this study. It could also play a certain extent of role for this result.

In conclusion it was not possible to detect damaged trees with simple threshold operation. It will be continued in next year to find an operational method with further attempt including data transform, classification and change detection and so on.

References

[1] Aplin, P., P. M. Atkinson, and P. J. Curran, 1999, Fine spatial resolution simulated satellite sensor imagery for land cover mapping in the United Kingdom. *Remote Sensing of Environment*, 68: 206-216.

[2] Bae, J. S., 2003, Reaccessment of historical, cultural and economical values of pine tree, *Proc. Symposium on Korean forum on forests for sustainable society*, Seoul, pp. 15-38

[3] Cho, H. K., W. K. Lee, and S. H. Lee., 2003. Mapping of Vegetation Cover using Segment Based Classification of IKONOS Imagery. *Korean J. of Ecology* 26(2) : 75-81.

[4] Definiens-Imaging, 2003, *eCognition User guide.*

[5] Franklin, S.E., Wulder, M.A. and G.R. Gerylo (2001) Texture analysis of IKONOS panchromatic data for Douglas-fir forest age class separability in British Columbia. *International Journal of Remote Sensing*, 22: 2627-2632.

[6] Kayitakire F., Farcy C. & Defourny P., 2002, IKONOS-2 imagery potential for forest stands mapping, *Proc. ForestSAT Symposium*, Edinburgh.

[7] Smith, G.M. and R.M. Fuller (2001) An integrated approach to land cover classification: an example in the Island of Jersey. *International Journal of Remote Sensing*, 22: 3123-3142.