ESTIMATION OF TREE DENSITY WITH HIGH-RESOLUTION IMAGERY IN THE ZARBIN FOREST OF NORTH IRAN (*CUPRESSUS SEMPERVIRENCE* VAR. *HORZONTALIS*)

H. Fadaei [a,] *, T. Sakai [a], T. Yoshimura [b], M. Kazuyuki [a]

[a] Department of Social Informatics, Graduate School of Informatics, Kyoto University, Kyoto, Japan - fadaei@bre.soc.i.kyoto-u.ac.jp
[b] Educations and Research Center for Biological Resources, Faculty of Life and Environmental Science, Shimane University

KEY WORDS: Tree density, Cupressus sempervirence, high-resolution, aerial Photograph

ABSTRACT:

Cupressus sempervirence var. *horzontalis* belong to the Cupressus family. This species is evergreen and grows within an elevation range of 290 meters and 1200 meters above sea level in the North of Iran. The extraction of texture features from high-resolution remote sensing imagery provides a complementary source of data for those applications in which the spectral information is not sufficient for identification or classification of spectrally similar landscape features. High spatial resolution satellite imagery and Aerial photography to estimate tree density have been applied. In this paper, objects and questions are; identification and delineation of tree crown, estimation of tree density by counting trees per hectare, the analyses of image segmentation, classification, texture and comparison with aerial photography, estimation of vegetation index and introduce a new method for tree density on base of pixel-based of classification. A new method of pixel-based classification has been used for tree density per hectare. A sample plot area about 900 ha was selected incorporating 15 sub sample plots chosen with 9 ha (300 ×300m) equal to 120 × 120 pixels for counting trees per hectare. Our method of measuring tree density was useful for estimation of biomass, enabling better decision making for natural resource managers in environmental fields. The results show that the proposed method could effectively reduce the over classification effect and achieve more accurate classification results, compared to existing method. The results of these analyses should be noted. We recommend a new method pixel based classification approach for extracting tree in the forest.

1. INTRODUCTION

1.1 General Introduction

Zarbin (Cupressus sempervirence var. horzontalis) is endemic of Iran. This forest as protected area by Government as a forest ecosystem, have important effects on human's life, in addition to ecological characteristics. Forest inventories have been carried out under the following conditions such as severe climate such as dry air, high temperature and strong sun. In addition, it`s required a lot of money, time, labor, many tools and helpers. Estimation of forest tree density at a relatively low cost and with little time consumption is required. Forest inventories become more cost-effective, less time-consuming and less labor-intensive by using remote sensing data. Aerial photography and satellite remote sensing have proved to be effective technologies for mapping forest vegetation at landscape to regional scale. Automatic segmentation of high-resolution satellite imagery is useful for obtaining more timely and accurate information. In 1940s, manual interpretation of medium and large scale aerial imagery for forestry emerged (Brandtberg, 1999). Since then, field inventory in combination with aerial photo interpretation has taken an important role in forest data collection. However, compared to the visual aerial photo-interpretation method, which is labor-intensive, time-consuming, and dependent on interpreter's experience, the automated aerial photo-interpretation method has many advantages.

1.2 Aim and objectives

This species is one of the worthiest species that can be found in the central area of Alborz in the North of Iran. In addition, this species can grow on calcareous marly lime stone rocks. It can be seen on calcareous marly limestone mountains. The purpose of this study is to determine the tree density by identification and delineation of tree crown, estimation of tree by counting trees per hectare, the analyses of image segmentation, classification, texture and comparison with aerial photography, estimation of vegetation index and introduce a new method for tree density on base of pixel-based of classification.

1.3 Background

There are many existing methods for tree density or counting on aerial photographs or remote sensing images. Dralle and Rudemo (1996, 1997) estimated tree positions by using scanned panchromatic aerial photographs of even-aged homogeneous stands of Norway spruce. Koukoulas and Blackburn (1998) involved the use of scanned aerial photographs and a combination of contouring and texture techniques to delineate tree crowns in broadleaved deciduous forests. In field of natural resources, spatially forest with the increasing availability of

* Corresponding author : Fadaei, Department of Social Informatics, Graduate School of Informatics, Kyoto University, Kyoto, Japan - 606-8501, Phone: +81-75-753-3137 Fax: +81-75-753-3133, Email: fadaei@bre.soc.i.kyoto-u.ac.jp

large-scale and high-resolution imagery, various algorithms have been developed for automatic individual tree recognition (Donald G. Leckie 2005). The common tree delineation methods consist of 1-Local maxima methods that search for the "top" of the convex mound, which usually corresponds to the sun-lit top of the tree. The simples group of tree-detection methods assumes that a local maximum in the image corresponds to the top of a tree. Blazquez (1989) developed an early example of such an individual tree counting approach for citrus trees in Florida, using digital aerial color-infrared (CIR) photographs. 2-Boundary-following approaches that identify tree edges between trees located within the showed regions (Gougeon 1995a, Warner et al 2006). When a topographic analogy is used to describe the surface of brightness value, the tree boundaries are represented by valleys, in the valley-finding method (Gougeon 1995a, Leckie et al 2005b); local minima are identified in the image. 3- Region-based tree segmentation is the direct search for a group of pixels that likely represent a single tree. Erikson (2003) used a region growing approach to segment singletree crowns in aerial photographs from a mixed-species boreal forest in central Sweden. (Culvenor 2002) developed Tree identification and delineation algorithm (TIDA), which uses the local radiometric maxima and minima to indicate the likely locations of tree centroids and boundaries, respectively. Brandtberg et al. (2003) based their approach on blob detection, or identification of convex regions in the image brightness surface. The blob detection is conducted at multiple scales, using all local maxima, at each scale, as seed points. 4-Template matching methods, it usually employs an optical crown model to generate synthetic image chips that represent individual tree (Pollock 1996, Larsen and Rudemo 1998). 5-Model-based methods in 3D, Gong et al. (2002) describe such as 3D model-based approach using stereo pairs, in which the problem is defined as an optimal tree model determination issue. As one of the simplest methods of tree identification, the local-maxima approach can be applied to relatively coarse-scale imagery, where the pixel size is not much smaller than size of the individual tree (Gufan Shao et al 2006). (Koukoulas et al 2005) introduced a new method is developed for extracting the locations of treetops by applying CIS (Geographical Information System) overlay techniques and morphological functions to high spatial resolution airborne imagery. Each of these approaches has been found to improve results in their intended applications.

2. STUDY SITE

2.1 Location

This research was carried out in Chaloos-Hassanabad valley in the North of Iran. The study site is located in the arid area of the northeast of Iran, where Zarbin trees grow, with the annual precipitation of 350mm and evaporation is 1039 mm (Figure 1).

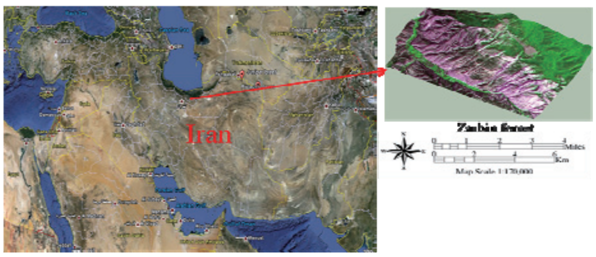


Figure 1. The study area

The area of the study site is 9km2 (3 x 3km) with the latitude and longitude of 36°29'59.56"N 51°21'48.09"E degrees, respectively. It is known that Zarbin (*Cupressus sempervirens var. horizontalis*) grows mostly at the elevation of 290 - 1,200m, and the elevation of the study site is at the elevation of 300 - 1,100m. The slope of the site ranges generally from 9 to 32 degrees. Among 100 (10 x 10) square grids with the side length of 300m, 15 sampling plots were randomly chosen for the analysis (Figure 2).

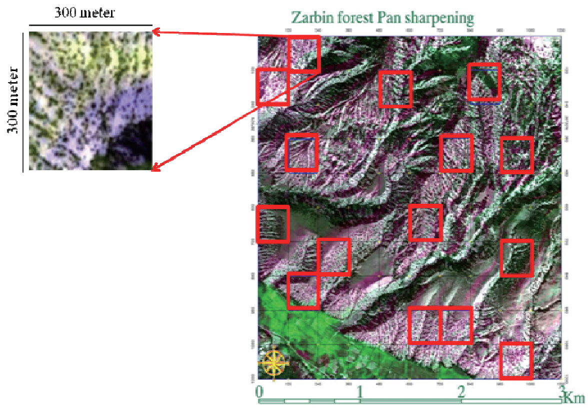


Figure 2. Position of sub-sample plots

The Zarbin trees in the study site are typically 20 - 30m high, with the crown diameter of 2 - 3m, fruit of this species is wooden with spherical shape. The height of fruit cons are between 2 to 4 cm and width is 3.2cm. Distribution of this trees with DBH>30 cm have are extremely rare. This reason caused to recognize and to be aware of the stand quantity, the current research tries to estimate tree density in this forest (Figure 3).

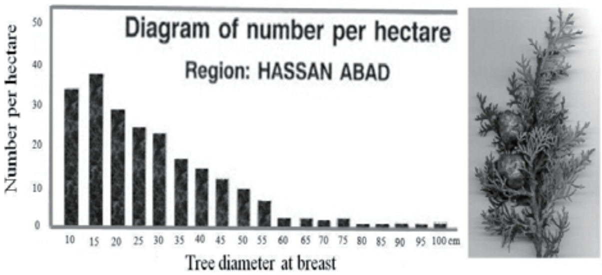


Figure 3. Distribution of this species

The distance between two Zarbin trees is often more than 3m, and between them in spots there are shrubs adapted to calcareous marly lime stone rocks, such as *lonicera arliarea* L., *Ficus careca* L., *Paliurus spina-christii* Mill., *Jusminum fruticans* L., and grass vegetation such as *Artemesia herba alba* Auct.plur., *Astragalus* . sp and *Dactilis glumerata* L.
Important of *Cupressus sempervirens var. horizontalis*; this species is one of the worthiest species that can be found in the central area of Alborz in the North of Iran. Properties of this forest have been performed on base of plenary study by the natural resources organization of Iran. Total area of region is 4781.25 hectare. Natural cypress is about 58, forestation 18.7, broad-leaves 9.2, open places 8, agricultural lands 5.4 and protective regions 0.8 percentage.

2.2 Image satellite data

We used the satellite imagery obtained by the ALOS (Advanced Land Observing Satellite), which was launched on January 24, 2006. Among three remote-sensing instruments that the ALOS has, the Panchromatic Remote-sensing Instrument for Stereo Mapping (PRISM) for digital elevation mapping and the Advanced Visible and Near Infrared Radiometer type 2 (AVNIR-2) for precise land coverage observation were used. The PRISM is a panchromatic radiometer with 2.5m spatial resolution at nadir, and has one band with the wavelength of 0.52 - 0.77µm (JAXA EORC). The AVNIR-2 is a visible and near infrared radiometer for observing land and coastal zones with 10m spatial resolution at nadir, and has four multispectral bands: blue (0.42 - 0.50 µm), green (0.52 - 0.60 µm), red (0.61 - 0.69 µm) and near infrared (0.76 - 0.89 µm) (JAXA EORC). The fusion of images from the PRISM and AVNIR-2 was used for the analysis.

2.3 Aerial photograph

The Army Map Service, USA, acquired the black & white aerial photograph used in this study with a Recording Technique of Vertical Reconnaissance in September 1956. The focal length of the camera, stereo overlap and aircraft altitude was 153.16 mm, 60% and 32000 ft respectively.

3. METHODOLOGY

3.1 Data pre-processing

3.1.1 Image pan sharpening:

Pan-sharpening algorithms are used to sharpen multispectral data using high-resolution spatial panchromatic data. The images must either be georeferenced or have the same image dimensions. Have been used **Color Normalized (Brovey)** sharpening to apply a sharpening technique that uses a mathematical combination of the color image and high resolution data. Each band in the color image is multiplied by a ratio of the high resolution data divided by the sum of the color bands.

3.1.2 Image registration:

Have been used registration to reference images to geographic coordinates and/or correct them to match base image geometry. Have been selected ground control points (GCPs) interactively from Image pan sharpening of ALOS. In the next step have been performed warping from saved image-to-image ground control points (GCPs).

3.2 Tree extraction

3.2.1 Image segmentation (object- based classification): Segmentation is the process of partitioning an image into segments by grouping neighboring pixels with similar feature values (brightness, texture, color, etc.) These segments ideally correspond to real-world objects. ENVI EX as the newest addition to the ENVI line of premier image processing employs an edge-based segmentation algorithm that is very fast and only requires one input parameter (Scale Level). Have been used feature extraction for tree extraction in the Zarbin forest – the process of finding and extracting specific objects of interest from high-resolution satellite imagery based on the object's spatial, spectral, and texture characteristics – is an essential task for extraction information from high-resolution imagery.
The feature extraction workflow in ENVI EX has been explained (Figure 4).

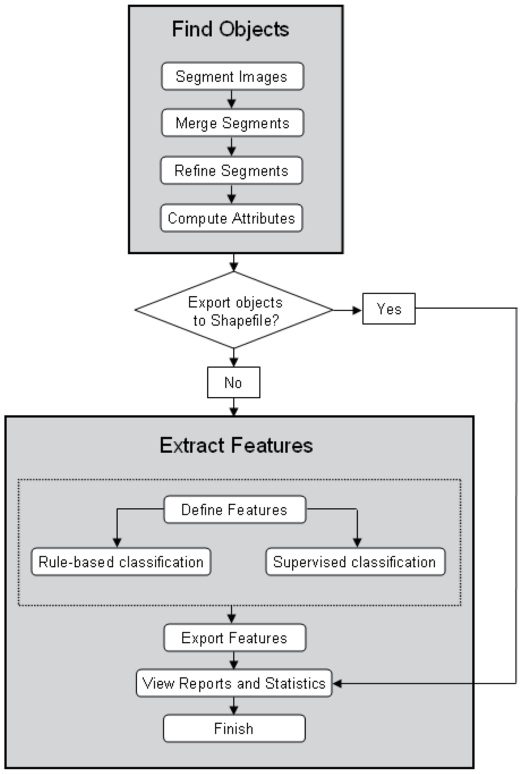


Figure 4.Feature Extraction Workflow

3.2.2 New method (Pixel-based classification): Have been introduced new method for tree extraction on pixel-based classification. Have been applied by the ENVI, the premier software solution for processing and analyzing geospatial imagery, announces the availability of a new service pack, ENVI 4.7 Service Pack 1 (ENVI 4.7 SP1), which helps to get information from imagery by increasing ease-of-use and adding efficiency to your image processing and analysis procedures. The tree extraction workflow in ENVI 4.7 SP1 has been explained (Figure 5).

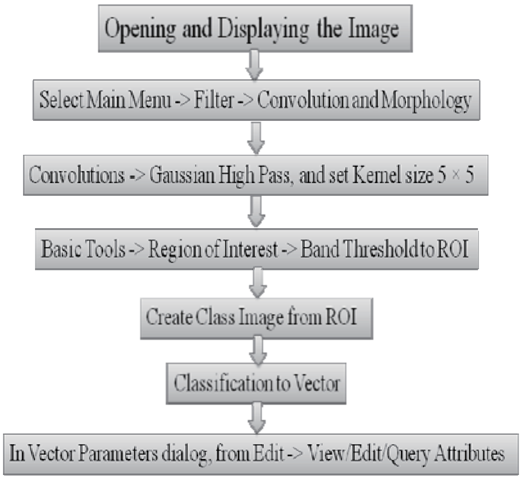


Figure 5. Tree Extraction Workflow (pixel-based)

3.2.3 Vegetation Analysis: Remote sensing offers an efficient way to estimate vegetation properties over large geographic areas. You can use spectral vegetation indices (VIs) calculated in ENVI to analyze vegetation properties. Have been used Atmospherically Resistant Vegetation Index (ARVI), the value of this index ranges from -1 to 1. The common range for green vegetation is 0.2 to 0.8 (Kaufman et al., 1996). Equation of this index as follows:

$$\mathrm{ARVI} = \frac{\mathrm{NIR}-\left(2\mathrm{R}-\mathrm{B}\right)}{\mathrm{NIR}+\left(2\mathrm{R}-\mathrm{B}\right)} \tag{1}$$

where NIR=Near Infrared, R = Red, G= Green, B= Blue

3.2.4 Texture: Have been analysis texture filters for extracting textural information from data. Use Occurrence Measures to apply any of five different texture filters that are based on occurrence measures. The occurrence filters available are data range, mean, variance, entropy, and skewness. Occurrence measures use the number of occurrences of each gray level within the processing window for the texture calculations. Texture refers to the spatial variation of image tone as a function of scale. Have been used Gray-Level Co-occurrence Matrix (GLCM) metrics variance of filter for texture. Equation as follows:

$$\sigma^2 = \sum_{i=0}^{N_g-1} \sum_{j=0}^{N_g-1} \left(i-u\right)^2 g\left(i,j\right) \tag{2}$$

where N_g is the number of gray levels, entry (*i.j*) in the Gray Level Co-occurrence Matrix and

$$u = \sum_{i=0}^{N_g-1} \sum_{j=0}^{N_g-1} i.g\left(i.j\right) \tag{3}$$

4. RESULTS AND DISCUTION

4.1 Results from processing image data and aerial photograph

The Gram-Schmidt spectral sharpening type was applied. A procedure is developed for combining high spatial resolution panchromatic data with lower resolution multispectral data in order to produce high spatial resolution digital data in multispectral form. Tree counting was started from pan sharpening image by two methods of tree extraction, first is image segmentation that is object-based and second method for tree extraction on based of pixel for total forest and sample plot (Table 1).

Table 1. Result of tree number on base of two method

Data	Object-based		Pixel-based	
(1)	9540*	3037**	67699*	25257**
(2)	18087*	5445**	133737*	41365**

(1) Aerial photograph (1956) and (2) Image pan sharpening (2009)

* indicate number of tree (Cupressus sempervirence var. horzontalis) for total Zarbin forest

** indicate number of tree (Cupressus sempervirence var. horzontalis) for sample plot

4.2 Results from tree counting on base of pixel for image data and aerial photograph

Here have been counted tree extraction on each sub sample plots by new method of tree extraction (Figures 5 and 6 table 2).

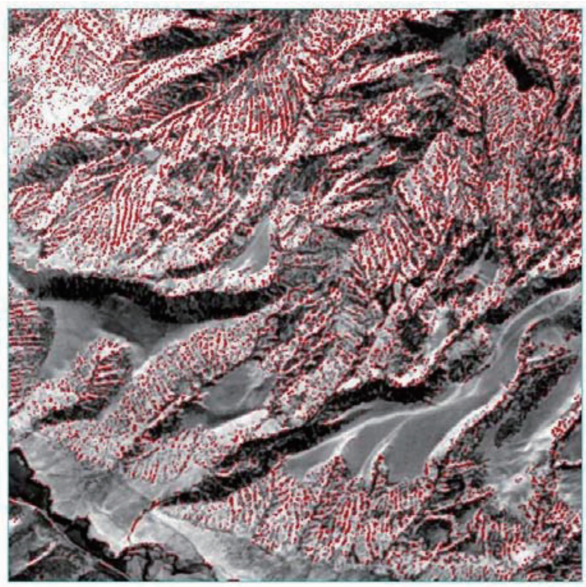


Figure 5. Tree extraction on pixel based for aerial photograph in sample plot

Figure 6. Tree extraction on pixel based for image pan sharpening

Table 2. Result of tree number on pixel based for sub sample plot

Plot	Image pan sharpening	Aerial photograph
1	400	396
2	479	319
3	523	455
4	504	251
5	443	388
6	491	352
7	519	391
8	421	175
9	497	329
10	379	228
11	554	203
12	455	161
13	427	346
14	456	274
15	423	307

4.3 Result from vegetation index

Dead, dry, or senescent vegetation have different spectral patterns from living vegetation, with the most scattering occurring in the middle infrared ranges. Have been applied Atmospherically Resistant Vegetation Index (ARVI) as a vegetation index. However, Zarbin forest with conifer species (Cupressus sempervirence var. horzontalis) has not reflectance in visible and near infrared wavelengths. For this, we compare with broad leaved high-density forest, now we observed Zarbin forest is non-photosynthetic vegetation (NPV) (Figure 7).

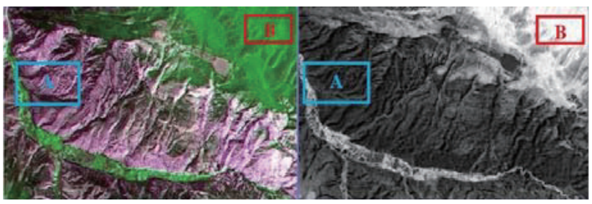
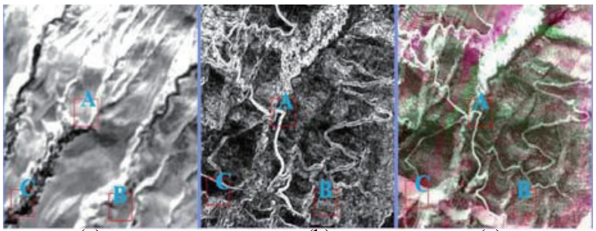


Figure 7. Result of ARVI index on study area

A; indicate Zarbin forest as non reflectance, ARVI value is (-)
B; indicate broad leaves high-density forest, ARVI value is (+)

4.4 Result from texture of aerial photograph and image pan sharpening

Have been used Gray-Level Co-occurrence Matrix (GLCM) metrics variance of filter for texture. In the texture observed as clearly some place has happening soil orison and planting with other broad-leaved species and construct forest road for plantation (Figure 8).



(a) (b) (c)

Figure 8. Result of (a): aerial photograph, (b): GLCM texture and (c): pan sharpening image

A: Forest road construction, B: plantation and C: soil erosion

5. CONCLUSION

This research focused to the several sections; first, we estimate tree density by counting tree in the study area. We applied object base and pixel based for tree counting. Image segmentation is based on object and new method that has been introduced is based on pixel for two kinds of data (aerial photograph and image pan sharpening) were applied. In image segmentation, you can extract multiple features at a time such as vehicles, buildings, roads, bridges, rivers, lakes, and fields. However, object-based have been used for image segmentation is not useful method for tree extraction (tree density) from high-resolution imagery. In this research has been new method on pixel based for tree counting introduced. This method has been applied for aerial photograph and image pan sharpening, that analysis indicates aerial photograph is not useful sources for tree density. Have been analysis Gray-Level Co-occurrence Matrix (GLCM) metrics variance for image pan sharpening. That has been indicated skillful method for texture. Other section about vegetation index, Atmospherically Resistant Vegetation Index (ARVI) has been proved Zarbin forest have not reflectance in the visible and near infrared wavelengths. Analysis of this region requires the hyperspectral data.

Acknowledgements
We are very thank full of Dr Ali Sheykholeslami for prepare some information about study area. In addition, we are grateful of Dr Vahid Etemad for giving us more details and his guidance about Zarbin forest.

References

Anys, H., A. Bannari, D. C. He, and D. Morin, 1994. Texture analysis for the mapping of urban areas using airborne MEIS-II images, Proceedings of the First International Airborne Remote Sensing Conference and Exhibition, Strasbourg, France, 3, pp. 231-245.

Blazquez, C.H., 1989. Computer-based image analysis and tree counting with aerial color infrared photography. Journal of imaging Technology, 15, pp. 163-168.

Brandtberg, T., 1999. Remote sensing for forestry applications - a historical retrospect. http://www.dai.ed.ac.uk/CVonline/LOCAL_COPIES/BRANDTBERG/UK.html

Brandtberg, T., McGraw, J., Warner, T.A., and Landenberger, R., 2003. Image restoration based on multi-scale relationships of image structures. *IEEE Transactions on Geoscience and Remote Sensing*, 41, pp. 102-110.

Culvenor, D., 2002. TIDA: an algorithm for the delineation of tree crowns in high spatial resolution remotely sensed imagery. *Computers & Geosciences*, 28, pp. 33–44.

Donald G. L., Francois A. G, Sally Tinis, Trisalyn N, Charles N. B, Dennis P., 2005. Automated tree recognition in old growth conifer stands with high resolution digital imagery. Remote Sensing of Environment, 94, pp. 311– 326.

Dralle, K. and Rudbmo, M.. 1996. Stem number estimation by kernel smoothing in aerial photos. *Canadian Journal of Forest Research.* 26, pp. 1228-1236.

Erikson, M., 2003. Segmentation of individual tree crowns in colour aerial photographs using region growing supported by fuzzy rules. *Canadian Journal of Forest Research*, 33, pp.1577-1563.

Gong, P., Sheng, Y., and Biging, G.S., 2002. 3D model-based tree measurement from high-resolution aerial imagery. *Photogrammetric Engineering and Remote Sensing*, 68, pp. 1203-1212.

Gougeon, F. A., 1995a. A crown-following approach to the automatic delineation of individual tree crowns in high spatial resolution aerial images. Canadian Journal of Remote Sensing, 21(3), pp. 274-284.

Gufan S. and Keith M. R. 2006. *Computer Applications in Sustainable Forest.* Management Managing Forest Ecosystems, Volume 11, pp 276.

Kaufman, Y.J. and D. Tanre, 1996. Strategy for Direct and Indirect Methods for Correcting the Aerosol Effect on Remote Sensing: from AVHRR to EOS-MODIS. *Remote Sensing of Environment* 55, pp.65-79.

Khosro, M., 1960. The design study of revival Hassan Abad Cupressus sempervirens var. horizontalis forests. Report of natural resources organization of Iran, Chaloos.

Koukoulas, S. and Blackburn, G.A., 1998. Digital image processing techniques evaluation for the extraction of tree crown geometry. *Proceedings of the 24th Annual Conference of the Remote Sensing Society,* University of Greenwich (Nottingham, UK: Remote Sensing Society), pp. 534-542.

Koukoulas, S. and Blackburn, G.A., 2005. Mapping individual tree location, height and species in broadleaved deciduous forest using airborne LIDAR and multi-spectral remotely sensed data. *International journal of remote sensing,* 26(3), pp. 431-455.

Larsen, M., and Rudemo, M., 1998. Optimizing templates for finding trees in aerial photographs. *Pattern Recognition Letters,* 19, pp. 1153-1162.

Leckie, D.G., Gougeon, F.A., Tinis, S., Nelson, T., Burnett, C. N., and Paradine, D., 2005b. Automated tree recognition in old growth conifer stands with high resolution digital imagery. *Remote Sensing of Environment*, 94, pp. 311-326.

Pollock, R.J, 1996. The automatic recognition of individual trees in aerial images of forest based on a synthetic tree crown image model. PhD thesis, Dept. Computer Science, University of British Colombia, Vancouver, Canada.

Warner, T.A., McGraw, J., and Landenberger, R.E., 2006. Segmentation and classification of high resolution imagery for mapping individual species in a closed canopy, deciduous forest. Science in China: Series E Technological Sciences, 49 (I), pp. 128-139.