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European Journal of Applied Engineering and Scientific Research, 2012, 1 (4):151-159

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ISSN: 2278 – 0041

A novel image processing technique for counting the number of trees in a satellite image

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ABSTRACT

This Paper Presents, an Image Processing Method for counting the number of trees in a High Spatial Resolution Satellite Image using Texture Approach. A hierarchical strategy is followed for detect, delineate and counting the trees in an image. Texture Approach Algorithm converts the RS Image in to HSI Image for more qualitatively analyze the image data. Image delineation is done approximately for using existing methods and also not gives the accurate tree count. This Algorithm gives accurate image delineation and also gives accurate tree count with the usage of Structured Element in Image. The fundamental process of an algorithm, simulation results are explained with image examples and limitations are discussed.

Key Words: *Tree crown Delineation, Texture Approach, Histogram Equalization, Thresholding, Tree crown count etc.*

INTRODUCTION

A Tree is a Perennial Woody Plant. It is most often defined as a woody plant that has many secondary branches supported clear of the ground on a single main stem or trunk with clear apical dominance [13]. Trees play an important role in maintaining Environmental conditions suitable for life on the Earth. Now-a-days Deforestation is increased due to lack of Knowledge and for other purposes like Industrialisation and Charcoal Production. This leads to Natural Calamities like Landslides, Floods and also increases Global Warming. For this Purpose to know how many trees are present in a Particular area. In a satellite image tree crown only visible i.e., the crown of a plant refers to the totality of the plants above ground parts including stems, leaves and reproductive structures extending from the trunk or main stems [14]. So count the number of tree crowns represents number of trees in a particular image.

In olden days count the tree crowns is done manually but it is labour intensive and includes too much of cost gives less accurate count. Recently, Remote Sensing Techniques helps to extract the Information from High Resolution Satellite Images. Several algorithms are failed to identify the number of tree crowns in complicate scene images because different kinds of entities are present like buildings, lamp posts etc. So using the texture difference between the saturation channel and intensity channel helps to detect and delineate the tree crowns in complicate scene images. The Texture analysis algorithm also gives accuracy in counting the number of tree crowns [1].

The rest of the paper is organized as follows: Section 2 represents the previous work. In Section 3 the basic image properties is discussed. In Section 4 the hierarchical steps of an algorithm is discussed in detail and in Section 5 presents the simulation results. Finally conclusion is made in Section 6.

2. EXISTING METHODS

Trees are important topographic objects in different fields of applications. Not only ecological aspects constitute the interest in trees but also different economic factors. Obviously, data about trees play an important role in forest inventories and forestry GIS applications [2]. Several algorithms have been developed for tree crown detection and delineation algorithms.

Tomas Brandtberg and Fredrik Walter proposed a Multiple-Scale Analysis Algorithm for delineation of individual tree crowns in high spatial resolution satellite images. Here tree crown outline identified as Zero Crossings with convex grey-level curvature. A modified centre of curvature was indicated for every edge segment pixel. Next, using these centre points form a primal sketch using an ellipse extended with the mean circle of curvature. A tree crown was identifies using this sketch [4].

R. Komura, M. Kubo, N. Kamata and K. Muramoto proposed Circle unification method to detect the tree crown by displaying the crown components as circles. Afterwards little tree area deleted and other tree crowns are unified for tree identification [5].

Mamoru Kubo, Shu Nishikawa, Eiji Yamamoto and Ken-ichiro Muramoto proposed Image-to-Map Rectification method. Here Field measured data is collected through Ground Control Points (GCPs). Using these data created the projected on-ground crown map consists of location and shape of individual trees and Image segmentation is done on satellite image .By comparing these two images tree crowns are identified [3].

Ryotaro Komura, Mamoru Kuba and Ken-ichiro Muramoto proposed Circle Expression and Watershed algorithm for delineating the tree crowns. Here the crown components are analyzed through circle area and make Radius Distribution Image (RDI). Delineate the crown area by applying watershed to RDI [6].

Pinz identified tree crown by utilizing the brightness changes in concentric circles out from tree apex [7]. Gougeon followed a valley following approach to delineate tree crowns [8]. Pouliot and King performed transect sampling around the tree apex, and modelled the transect data with a four order polynomial to determine the boundary [9].

The above methods can deals a wide range of remote sensing data to detect and delineate tree crowns. But these are computation intensive and the tree crowns count is still not perfect. The idea of our approach is count the number of tree crowns using texture analysis based algorithm for a complicate scene using simple image process.

3. REVIEW OF IMAGE PROPERTIES

The basic knowledge required on the following image properties to extract and analyze the image.

3.1 Texture

Texture refers to the visual patterns that have properties of homogeneity that do not result from the presence of only a single colour or intensity. It is a natural property of virtually all surfaces, including clouds, trees, bricks, hair, and fabrics. It contains important information about the structural arrangement of surfaces and their relationship to their surrounding environment. $Fig\ (i)$ shows a few types of textures [10].

$Fig\ (i)$: **Different Types of Textures**

3.2 Colour

Colour is one of the most widely used visual features for images. It is a Conception that depends on interaction of light with human visual system. It is a product of Illuminant, Surface Spectral Reflectance and Sensor Sensitivity. It is relatively strong on background complication and independent of Image size and Orientation. Several issues might occur to extract the colour features in an image like colour space, colour quantization and the choice of similarity function. Colour space nothing but the colour of an image says numerically. Different colour spaces like RGB, HSV, HSI, YUV and CIE L*a*b to describe their entities.

3.3 Histogram

Histogram is a graphical representation of tonal distribution of digital image i.e., the histogram of digital image with the intensity levels in the range [0, L-1] is a discrete function [11].

$$h(r_k) = n_k \quad (1)$$

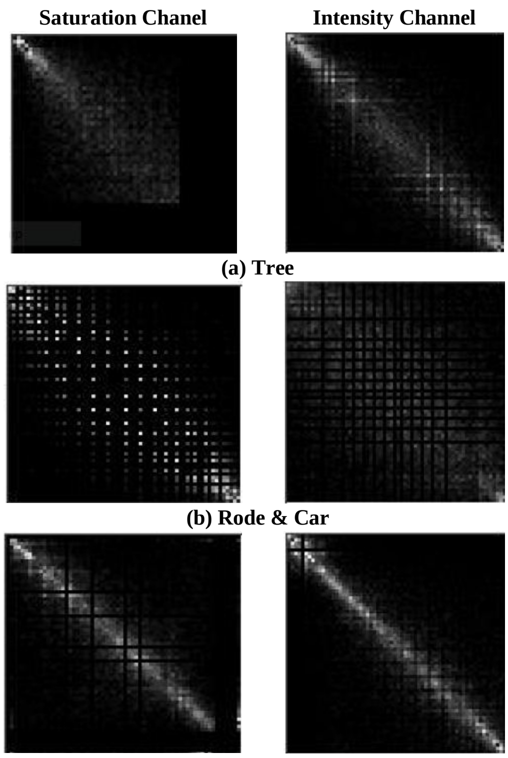
Where r_k is the intensity value.

n_k is the number of the pixels in the image with intensity r_k .

$h(r_k)$ is the histogram of the digital image with gray level r_k .

MATERIALS AND METHOD

Texture difference between Intensity Channel and Saturation Channel is different for tree crowns. So use this property detect the tree crowns. $Fig\ (ii)$ shows the texture difference of Intensity and Saturation Channel images after histogram equalization [1].



$Fig\ (ii)$: **Co-occurent Matrix of Saturation Channel and Intensity Channel of Several typical kinds of entities**

Detect the number of tree crowns from a satellite image using Texture analysis algorithm have several stages. The flow chart for the Texture Approach algorithm is shown in the $Fig\ (iii)$

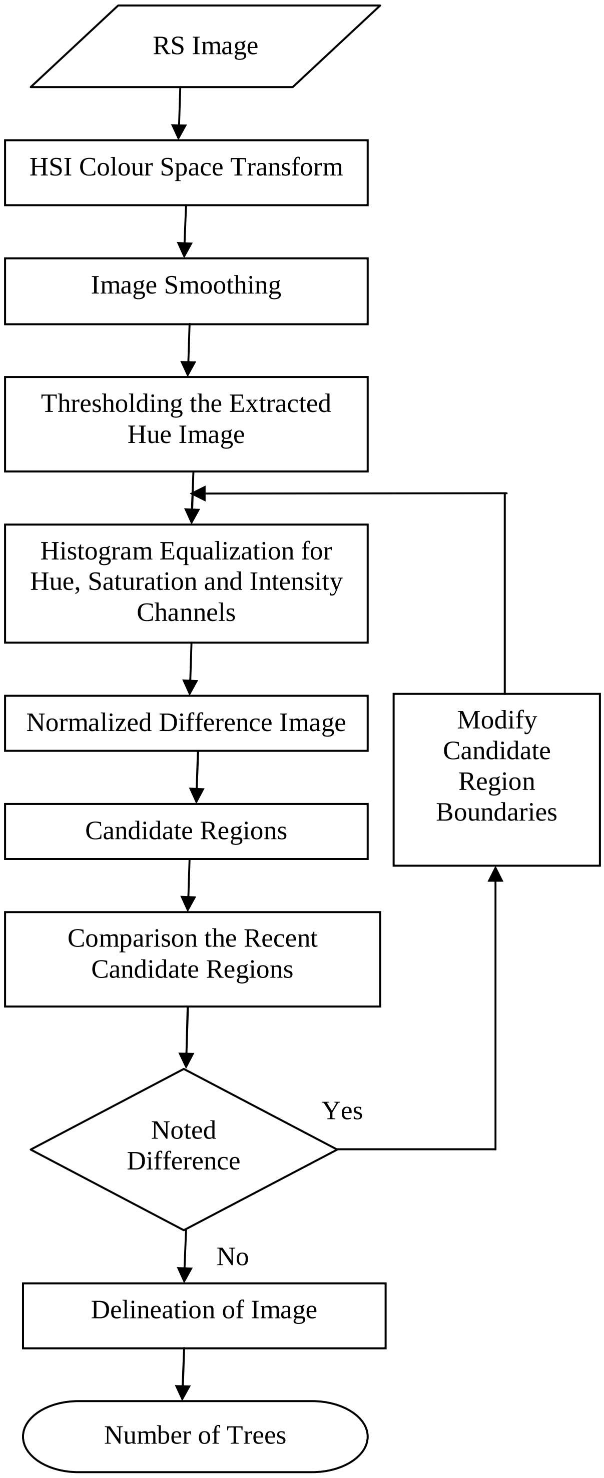


Fig (iii): Overview of Texture Approach Algorithm

4.1 HSI Colour Space Transform
A High Spatial Resolution Remote Sensing Image is converted in to HSI colour space transform for identifying the texture difference between Saturation Channel and Intensity Channel.

Hue is an attribute that describes a pure colour like pure Yellow, Orange or Red. It is also defines a mixture of two colours like combination of Red-Yellow or Yellow-Green. Saturation gives a measure of the degree to which a pure colour is diluted by a white light. Brightness is a subjective descriptor that is practically impossible to measure. It embodies the achromatic notion of Intensity and is a key factor in describing colour sensation [12]. The Hue Component of each RGB Pixel is obtained using the equation.

$$H = \begin{cases} \theta & \text{if } B \leq G \\ 360-\theta & \text{if } B > G \end{cases} \quad (2)$$

Where

$$\theta = \cos^{-1}\left\{ \frac{\frac{1}{2}[(R-G)+(R-B)]}{[(R-G)^2+(R-B)(G-B)]^{1/2}} \right\}$$

The Saturation Component is given by

$$S = 1 - \frac{3}{(R+G+B)}[\min(R,G,B)] \quad (3)$$

The intensity component is given by

$$I = \frac{1}{3}(R+G+B) \quad (4)$$

The result of this stage is concatenated HSI colour space image.

4.2 Image smoothing

Image Smoothing means to remove the noise in the Concatenated HSI Image. Noise reduction is done by using Gaussian Filtering. The equation of Gaussian function in one dimension is

$$G(x,y) = \frac{1}{\sqrt{2\Pi\sigma^2}} e^{-\frac{x^2}{2\sigma^2}} \quad (5)$$

Where σ is Standard Deviation. Here Gaussian filtering is done with filter size = 11X11 and σ =2 for reducing the noise and smooth the image.

4.3 Threshold the Extracted Hue Image

In this stage Threshold the Hue image to segregate the similar hue values. Thresholding creates binary images from grey level ones by turning all pixels below some threshold to zero and above some threshold to one mainly used for Image Segmentation. Suppose g(x,y) is a thresholded version of f(x,y) at some global threshold T.

$$g(x,y) = \begin{cases} 1 & \text{if } f(x,y) \geq T \\ 0 & \text{if } f(x,y) < T \end{cases} \quad (6)$$

Here Thresholding segmentation applied on extracted hue channel image to segregate the image in to regions share similar hue values. Small regions are merged in to big one so as to form the candidate region.

4.4 Histogram Equalization for Hue, Saturation and Intensity Channels

Histogram Equalization is done to enhance the image properties for detects the tree crowns. Histogram Equalization is a technique that produces a gray map which changes the histogram of an image and redistributing all pixels values uniformly.

$$h[i] = \text{constant for all of } i. \quad (7)$$

It mainly used for Image Enhancement and also increasing dominance features in an image by decreasing the ambiguity between different reasons of an image like converting the low contrast image to high contrast. [11].
Let X is the image composed of L discrete gray values denoted as

$$X = \{X_0, X_1, \ldots\ldots, X_{L-1}\} \quad (8)$$

For given image X, the probability density function is denoted as

$$p(X_k) = \frac{n^k}{n} \quad (9)$$

Where k=0, 1... ,L-1.

n^k = Indicates number of times that the level X_k represents in the image X.

n = Total number of samples in input image.

$p(X_k)$ =Histogram of the input image which represents the number of pixels that have a specific intensity X_k

Histogram Equalization is performed on intensity channel to flat its histogram. Then afterwards Saturation channel is tuned to fit that of intensity channel.

4.5 Normalized Difference Image

Normalised Difference image is help to detect and delineate tree crowns. Generally this image is calculated from two bands of image data. These bands may be single or multiple, in first case results single band ND image and later results multi-band ND image. Here normalised difference image is calculated as follows:

$$D = (SE - IE)/(SE + IE) \qquad (10)$$

Where D = Normalised Difference Image.
SE=Adjusted Histogram Equalization of Saturation Channel.
IE= Tuned Histogram Equalization of Intensity Channel.

4.6 Candidate Regions

To elevate the candidate regions in the image using Normalized difference image. So first the background related pixels set to zero. Then the regions are elevated for identifying the crown part of the tree. There are several texture features like Entropy, Energy and Contrast are calculated to decide whether that region belongs to candidate or not. Here takes Entropy as a deciding factor. It is a statistical measure of randomness used to characterise the texture of input image. It is defined as

$$e = -sum(p.*\log 2(p)) \qquad (11)$$

Where P counts the histogram counts returned from histogram equalization images [12].

4.6 Delineation Image

Lastly, two recent candidate regions are compared if there is any difference then modify the candidate region boundaries and repeat the process from Histogram equalisation. Otherwise map all the candidate regions as tree crowns and draw out their boundary to create the delineation result.

4.7 Trees Counting

Structuring Element is used to identify number of tree crowns in an image. It is defined as a shape, used to interact with a given image, for conclude on how this shape fits or misses the shapes in the image [17]. On Delineated image apply structuring element function to identify the candidate regions and to remove the small elements related to other entities in the image like lamp posts, vehicles etc. Finally it gives number of tree crowns in a particular image.

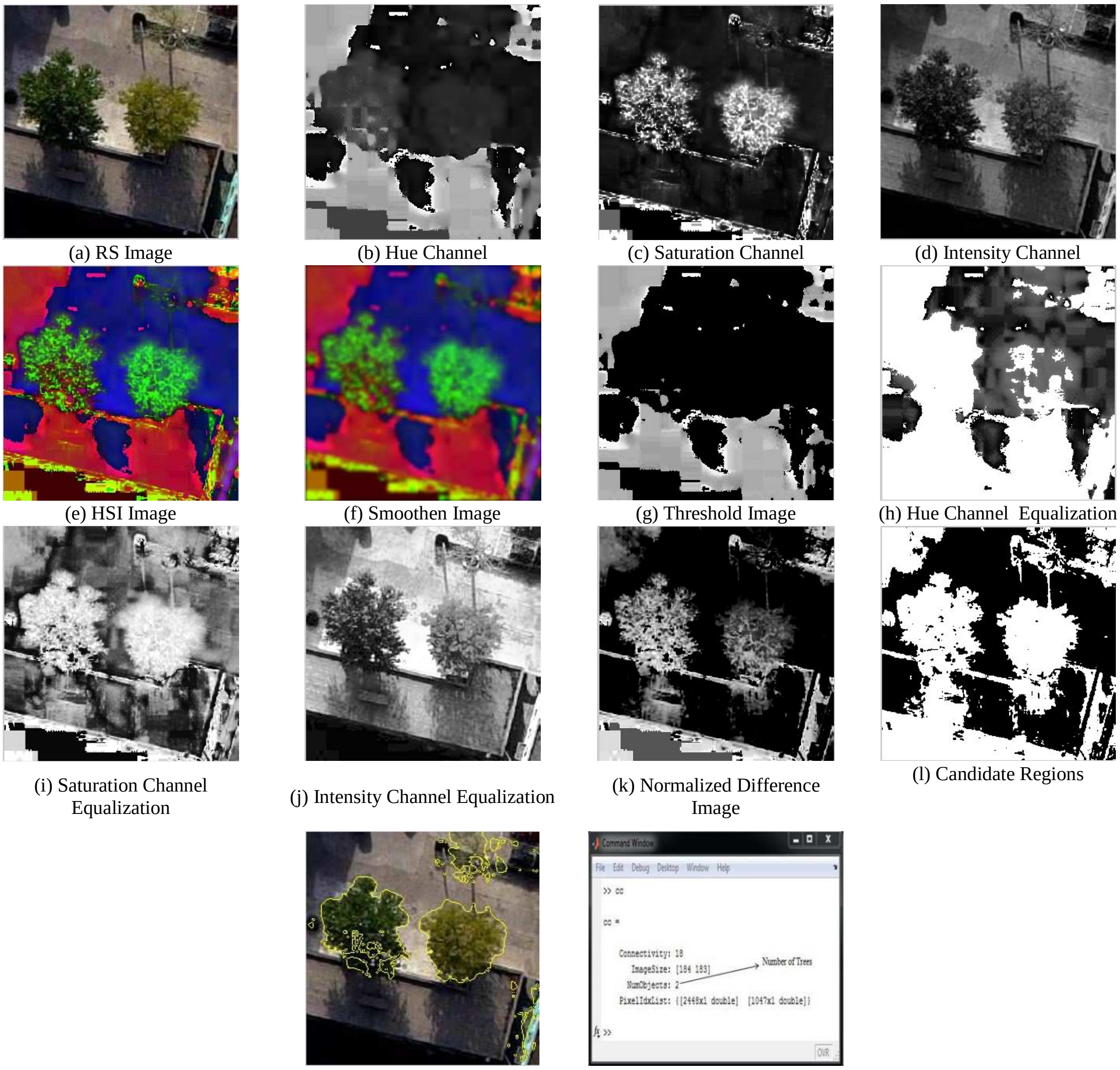
RESULTS AND DISCUSSION

A High Spatial Resolution RS Image is analysed to count the number of tree crowns in this algorithm. This method is suitable for several kinds of scenes are involved in these images: dispersed trees in city, dispersed trees beside highway and dense trees in forest. The input RS image is shown in $Fig\ iv(a)$, from that figure the extracted Hue, Saturation and Intensity components are shown in $Fig\ iv(b),\ iv(c)\ and\ iv(d)$.From these extracted images concatenated the HSI image shown in $Fig\ iv(e)$.

Gaussian filtering is done in next stage to reduce noise and smooth the image in $Fig\ iv(f)$. Threshold segmentation applied on the Hue channel to share similar hue values shown in $Fig\ iv(g)$. Histogram equalization is done for all channels to enhance the image properties shown in $Fig\ iv(h), iv(i)\ and\ iv(j)$. From that create a Normalized Difference Image to identify the tree crowns shown in $Fig\ iv(k)$.

Candidate regions are identifying to set the negative value pixels i.e., background pixels in image to zero. Then, the regions separated by the background are recognized. In each region texture feature such as entropy is calculated and decide it is candidate or not. The final candidate regions image shown in $Fig\ iv(l)$.

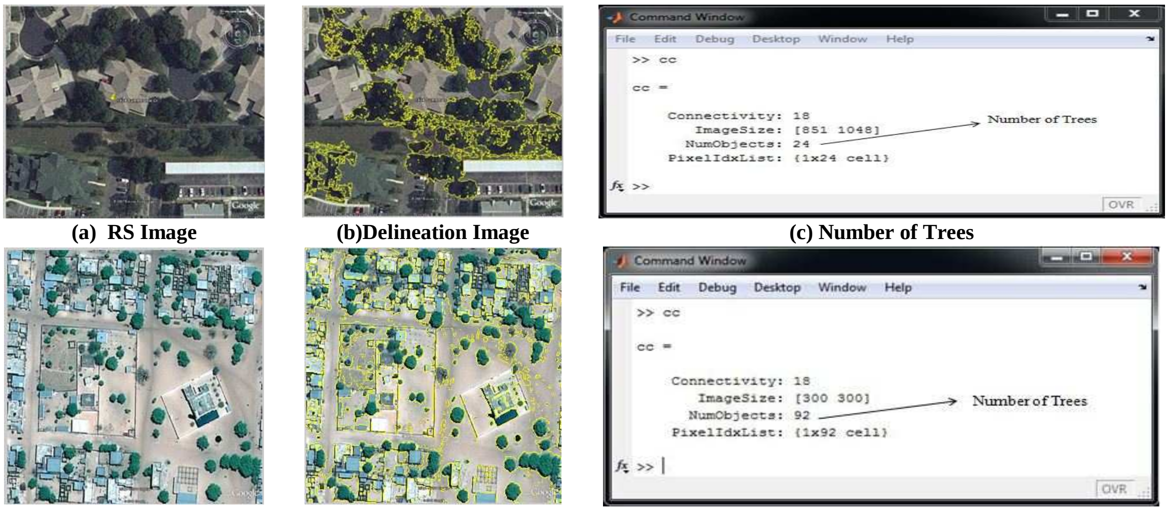
The recent two candidate regions are compared if there is any differences between them go back to histogram equalization stage and repeat the process. Otherwise map all the candidate regions and draw out their boundary for delineation image shown in $Fig\ iv(m)$.Finally from the delineated image apply Morphological function, Structured Element to remove the non tree components by opening function to count the number of tree crowns as shown in $Fig\ iv(n)$.



(a) RS Image (b) Hue Channel (c) Saturation Channel (d) Intensity Channel
(e) HSI Image (f) Smoothen Image (g) Threshold Image (h) Hue Channel Equalization
(i) Saturation Channel Equalization (j) Intensity Channel Equalization (k) Normalized Difference Image (l) Candidate Regions
(m) Delineation Image **(n) Number of Trees**

$Fig\ (iv)$: **Simulation Results of Texture Approach Algorithm**

The Texture based analysis algorithm gives accuracy index of the tested remote sensing image data is 85.1%. Dense canopies are well suited for this algorithm and less accurate in sparse canopies because texture features varied. The different RGB images and their Delineation result are shown in below $Fig\ (v)$.



(a) RS Image **(b)Delineation Image** **(c) Number of Trees**

(d) RS Image **(e)Delineation Image** **(f) Number of Trees**

Fig (*v*) : **Simulation Results of Algorithm**

The main draw back in existing methods [7-9], is the over lapping tree crowns are counted as a single tree. So they cannot give the accurate tree count. In the proposed method, using texture approach algorithm we can find accurate tree count as shown in *Fig* (*v*) .

CONCLUSION

A Tree Crown Delineation and Count the number of trees in a high spatial resolution Rs image methodology is developed. It is well suited for dense canopies and complicated entities present in images. This algorithm works accurately at less than 10cm pixel spacing. The major limitations are shadow is also considered a crown and if crown and other entity have same colour that object also considered as crown.

Furthermore, it is become to possible to obtain the Neighbouring tree crown partition, Radiation rectification and crown identification if tree crown and other entities have similar colour.

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