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# Principal Component Analysis based Assessment of Trees Outside Forests in Satellite Images

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## Abstract

This Paper Presents, an automated Matrix Laboratory (MATLAB) based procedure for assessing the number of tree crowns in a High Resolution Satellite Image based on Principal Component Analysis (PCA) algorithm. This automated method comes into picture to reduce the manual power, time and money. PCA involves in a mathematical approach in usage of orthogonal transforms for converting a given set of correlated observed values into a set of modified grey levels of linearly uncorrelated variables and these newly generated values are called principal components. Then a bounded set of thresholding values are used to identify the trees, Laplacian of Gaussian (LOG) operator is used to find and mark the boundaries of trees to extract the tree crowns available in the test site. Finally, count the number of tree crowns by using available morphological open and close operations with the help of connectivity methods. The results obtained are matched with manual approximated count and the accuracy of algorithm is done by testing on 20 different sets of test areas the accuracy achieved is 86.6 and it is better than NDVI and Watershed segmentations. Further improvement is possible when this method is combined with NDVI.

**Keywords:** Blob Detection, Counting Trees, LOG, PCA, Remote Sensing, Tree Crown Delineation

## 1. Introduction

Trees are an important natural resource for living beings on earth they are fulfilling important needs of livelihood like Food and oxygen. There acts like shelter and maintains ecosystem balance by reducing carbon dioxide in the air and helpful for reducing ground temperatures. So by finding the number of trees present in a given area one can have a continuous monitor of that area and can estimate changes and can take precautionary steps ahead.

The main objectives are identification, delineation and count the number of tree crowns from high resolution satellite images. For that we used PCA and LOG (Blob Detection), to enhance the level of accuracy to identify the tree crown segments. Initially consider the high resolution images from satellite as input to the proposed method and then extract the tree crown parameters and finally the tree crown count is given in a particular satellite data[1].

The living environment on earth is a combination of different proportions of vegetation areas, undergrowth plants, plain soil, lawns, construction areas and roads. So we need to distinguish these objects from real trees by their shape, color features and area occupied by that object in that image. This can be done by Mathematical Morphology (MM).

In this paper three major steps were developed to find the tree areas. First step the PCA can reduce the atmospheric noise present in image and decrease the dimensionality of the satellite data without loss of

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the information. In Second step, Adaptive Histogram Equalization (AHE) is applied for improving the details in the image, it calculates numerous histograms, each histogram corresponding to a small window unit of the image, and uses the histogram values for redistributing the brightness values in the image. So, AHE is best suited for improving the local features of image like contrast of objects in an image and bringing out more details of the objects. In Third step, LOG refers to mathematical procedure used for detecting areas like circular (blob) in an image that shows variations in properties, such as brightness, grey level values compared to regions surrounding objects. Acts like edge detection.

## 2. Background Work

Several automated procedures have been developed for extraction of vegetation regions. And these procedures were grouped into four major classes by Le Wang et.al.2004 LM-local maximum based procedures, Contour Based (CB) procedures, Template Matching (TM) based procedures & 3D model based procedures.

The Local Maximum based methods[2,3] developed based on an assumption that the top of the tree-crown gray level value is positioned close to tree-top Hence, by using a filtering methods on the satellite data for finding the local maximum, tree positions can be extracted.

The CB methods[4,5] encounters to find the gray level changes between tree crowns with respect to background. The key approach used is either to follow the grey level low intensity values primarily in the satellite data or to delineate the tree boundary with edge detection procedures.

The TM methods[6,7] comprises a typical template generation and a matching algorithm. Automatically, a sequence of small tree crown images is built to describe a tree crown looks like at different positions and situations in a satellite image by considering both the tree tops and color & Texture properties. When this template tree crown information is gained, a sliding window adjacent relationship procedure is employed for the best matching of trees crowns.

3D based methods[8,9] uses a different approach for 3D based model image matching for obtaining an enhanced tree surface reconstruction. These methods utilize a simple basic tree surface model that uses the tree shape, color, gray level value, illumination, and a sensor model.

In[10] proposed a segmentation procedure for tree crowns based on PCA method with the combination of Marker controlled watershed segmentation. Although it gives promising results for forest areas, Marker controlled watershed segmentation is not fit for urban areas because of the limitation of over segmentation. In this paper we make use of this PCA by combining with blob detection LOG and Morphological Operations to segment the tree crown and count in urban areas.

## 3. Proposed Method

In general, the satellite images suffer from atmospheric noises and also satellite images are very large in both memory size and dimensionality. The PCA will reduce the dimensionality of the image without loss of the object information; it preserves the information in small no. of components

**Figure 1.** Input satellite image.

Figure 1 represents input test data taken for analyzing the algorithm.

PCA applies an orthogonal transformation procedure of matrices for converting a given set of observed values into a new set of modified grey level values of linearly uncorrelated array variables called principal components. The number of newly formed principal components might be less than or equal to the number of taken input observed values. The procedure of calculating PCA is clearly explained in[11].

The Process of finding principal Components can be summarized as follows:

- Get input matrix (image) data.
- Subtract the mean of each matrix dimension.
- Find the Covariance matrix.
- By using covariance matrix find Eigen values and Eigen vectors.
- Take Diagonal elements of matrix as vector.
- Sort the extracted variances in above step in decreasing order.
- Project back the matrix data set.

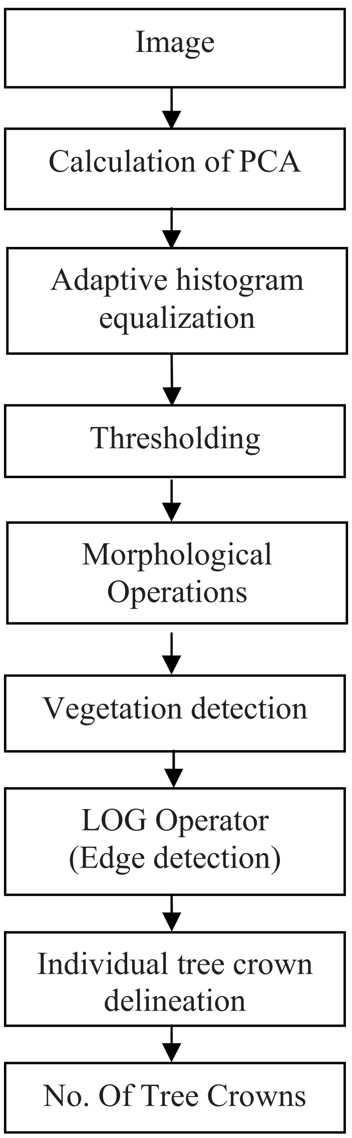


**Figure 2.** Flow graph of the algorithm.

Figure 2 representing the flow graph of the proposing algorithm for segmentation and counting of tree crowns.

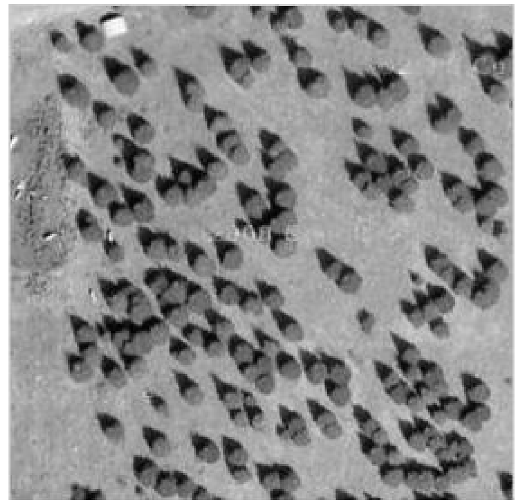

**Figure 3.** Principal component image.

Figure 3 shows the first principal component image. It preserves object information without losing.

AHE[12] used to improve local contrast in images. AHE differs from normal Histogram Equalization (HE) procedures like AHE computes several histogram values, each histogram corresponds to a different unit of the satellite image usually small blocks, after calculating it uses HE values to redistribute the grey level values in the image. Therefore, AHE best suited for refining the local contrast of objects present in an image. Figure 4. represents the process of AHE getting new brightness values.

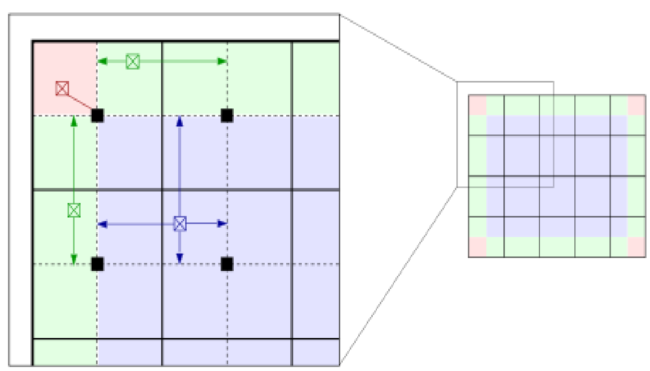

**Figure 4.** Adaptive HE procedure.

After applying these two steps trees are clearly visible and the edges are more separable from background. Now by applying simple thresholding mechanisms the trees can be separated from background. As shown in Figure 5.

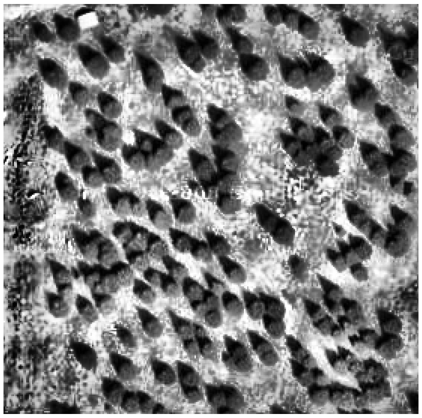

**Figure 5.** AHE output.

Thresholding is a process of converting an image into a two level image with the help of ideal grey level value according to object of interest. Usually after setting a threshold value image grey levels are grouped into two states using 1 and 0. Grey level value 1 marks the pixels that belong to true foreground or object of interest and 0 grey level value represents background regions.

If a(x,y) is an intensity image, then the thresholded image b(x,y) illustrated in equation form as

$$b(x,y) = \begin{cases} 1, if\, a(x,y) \geq T \\ 0, if\, aJ(x,y) < T \end{cases}$$

Then any pixel position (x, y) for which a(x, y) ≥Tis considered as interested object pixel; otherwise, the pixel position is called a background pixel region.

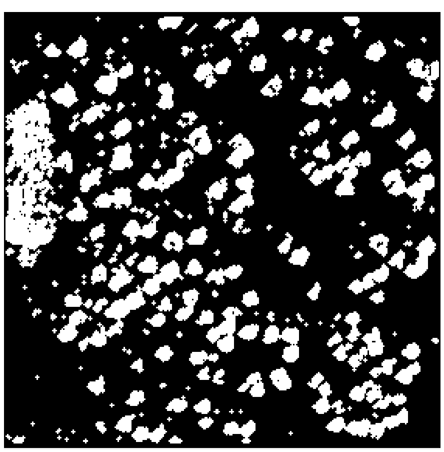

**Figure 6.** Extracted tree crowns.

Figure 6 clearly showing the tree areas as a segmented result after thresholding applied. But some noise is also included while processing these steps.

Mathematical morphology helps to remove noise elements present in these binary images. These methods use the existing dilation and erosion operations (morphological opening and closing). These processes use a Structuring Element (SE) of various sizes and shapes depending on the object of interest. The Figure 7 shows the noise cleared image after applying erosion and dilation processes using a morphological SE.

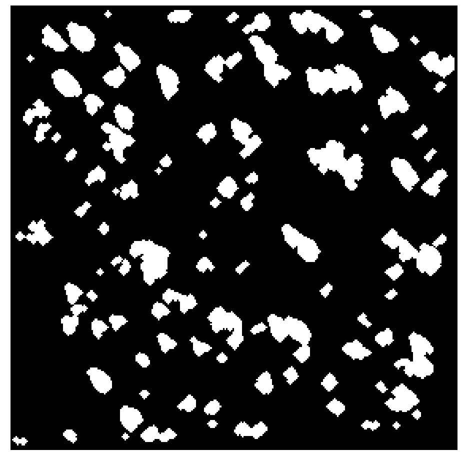

**Figure 7.** Noise eliminated image.

Edge detection is needed to delineate the tree crown so that the boundaries of tree crowns fit into edge image. In this way false segmentation of trees can be identified. There are several algorithms available for extracting edge information from binary images the LOG operator works good for finding of circular object edges. This is one of the "Blob detection" techniques. Figure 8 shows the edge detected image.

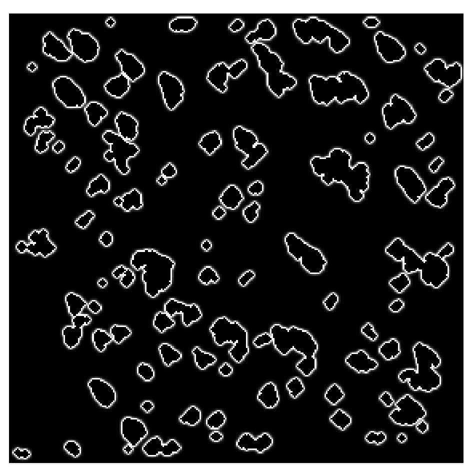

**Figure 8.** Edge detected image.

In LOG edge detecting procedure the given input image is convolved with a Gaussian window given in following equation.

$$T(x,y,t) = \frac{1}{2\pi t} e^{-\frac{x^2+y^2}{2t}}$$

This equation gives in highly correlated positive responses for low grey level circular region of degree $\sqrt{2t}$ and negative responses for brighter grey level circular object regions of smaller size. The difficulty occurred for LOG is at a single level value, is that the detector response is always dependent on the relationship between the adjacent connectivity of the pixels and also the region of coverage of the circular object structures in the image data.

## 4. Experimental Results

The Proposed algorithm was implemented in MATLAB R2012a (7.14.0.739). and tested on 20 different types of satellite locations and the data are taken from Google search engine. The average accuracy achieved is 86.6%. Figure 10 is second data set taken for testing The Figure 9 and Figure 11 showing delineated output of the algorithm. In this the edge detected image is overlapped on original satellite data to check whether the algorithm identified tree locations or not.

**Figure 9.** Delineated output image.

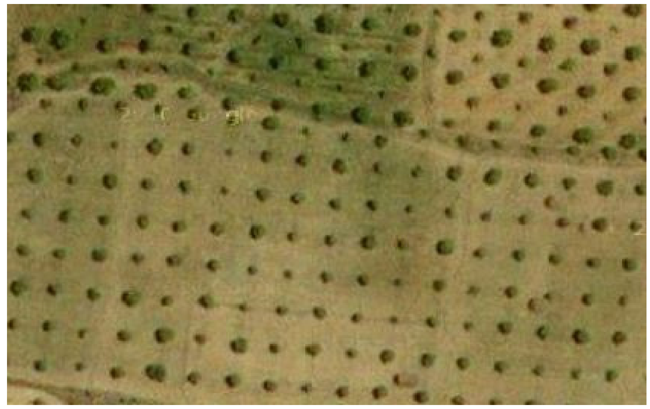

**Figure 10.** Satellite test data II.

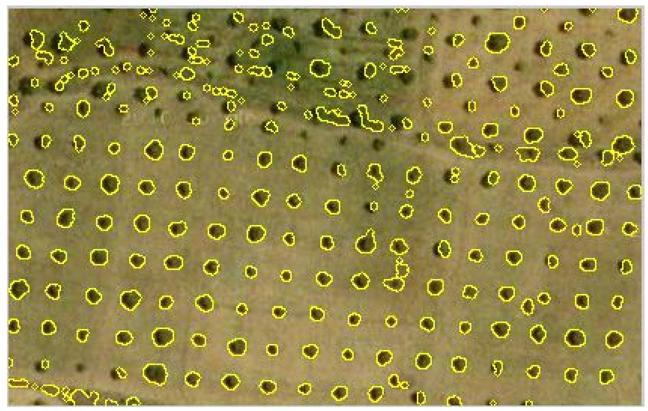

**Figure 11.** Delineated output image.

For the second test satellite image a total of 264 tree crowns was identified.

## 5. Discussions

Note: The Manual Count is Approximation only.

The algorithm discussed in this paper shows promising results, when compared to traditional NDVI and texture based algorithms. Table 2 shows the % accuracy of the algorithm for test set 1 and 2 and over all is given after testing on 20 different test sets. Table 1 showing the parameters need to adjust depending upon the resolution of the satellite data taken. AHE may over amplify noise in object surrounded regions. So, we need to take an extra care while implementing the code. Because trees are of different sizes, the value of SE parameters could be varied. For this method, we assumed a minimum window size of 3x3.

**Table 1.** Parameters values

| *Parameters* | *Pixel values* |
|---|---|
| t or σ used for LoG operator | 1 |
| SE used in MM operation | 3 by 3 |

**Table 2.** Agreement of the extracted tree crown between the approximated and proposed method

| Manual Count | | Count obtained | % of tree Count |
|---|---|---|---|
| Image 1 | 110 | 95 | 86.3 |
| Image 2 | 280 | 264 | 94.2 |
| Average (20 sets) | | | 86.6 |

## 6. Conclusion

The PCA based tree crown delineation was presented along with an accuracy of 86.6 in urban satellite images. Further there is a scope for improving results also by careful selection of thresholding and SE values. This algorithm is tested over 20 data sets in MATLAB.

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