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# Estimation of Tree Count from Satellite Imagery through Mathematical Morphology

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***Abstract*— Forest Management is vital for maintaining environmental stability and ecological biodiversity. A regular forest inventory of the forested areas can help us intricately view the causes of decline of forests in the area and assist in decision making. The main objective of this paper is estimating tree count using satellite images. Traditional methods for counting trees are labor-intensive inventory in the field or on an interpretation of large scale aerial photographs. However these methods are costly, time consuming and not applicable to large, isolated areas. Satellite remote sensing technology is the effective method for management and monitoring of forest resources. Tree Counting is a very tedious and inaccurate process, depends on image data. The counting of trees becomes extremely difficult when the satellite image is of low resolution and if the trees are closely located. Tree Counting is done in proposed system by morphological reconstruction and watershed transform to delineate touching crowns.***

***Keywords*— Forest Management, Remote Sensing, Satellite Image, Morphological operations, Morphological Reconstruction, Watershed Transform.***

## I. INTRODUCTION

This Forest inventory information has been important with respect to forest management. In addition, for sustainable forest management, more information is needed, not only for planning future forest management, but also for recording the previous status of the forested area ([1]). Furthermore, single tree level forest information has been essential for various forest applications, such as monitoring forest regeneration, forest inventory, and evaluating forest damage ([2]). Therefore,

detailed forest information such as tree counts, tree heights, crown base heights, diameter at breast height (DBH), and forest biomass, are critical for the effective management and quantitative analysis of forests ([3]). In the forest industry, manual interpretation of aerial photographs and use of digital photogrammetry techniques are common for evaluating tree species composition, tree density and height in many countries. A more recent source of information on the acquisition of spatial data by forest management agencies can be found in [4], where 2 out of 25 agencies reported use of medium resolution satellite imagery for mapping forest details while many agencies used 'simple graphical methods' to transfer data from aerial photographs. [4] also reported 'It is surprising to find this labor-intensive approach still widely used by forest management agencies in developed countries' taking into account that the cost of using photogrammetrical methods is not much high. Crown counting can be difficult and inaccurate. Much depends on the quality of the image data, the physiognomy of the stand, and the skill and experience of the photointerpreter. Howard (1991) cites a minimum spacing of ±4m between trees for large scale aerial photography, and that most accurate counts can be obtained in boreal forests, open grown woodlands and recently thinned plantations [6]. Friedl and Brodley [7] have discussed about satellite imagery, a remote sensing technique, which is convenient for large scale surveys and has been widely used for land coverage and habitant mapping for different applications, but image processing techniques have been employed for has a low resolution and can be expensive. A. Haaara and S. Nevalanine [8] however have discussed aerial photography that can provide higher resolution and allows monitoring of forest health and identification of tree species at an acceptable accuracy. [9] Gougeon developed a valley-following algorithm for the isolation of individual crowns in Canadian Boreal forests.[10,11] Pollock and Larsen developed algorithms that delineate crowns based on the optimal match of predefined geometric shapes with local radiometric values. Brantberg and Walter performed tree delineation in high resolution imagery using convex shaped edge segments, local maxima and region growing. [12] In Culvenor's TIDA method, the local radiometric maxima and minima are the primary image features used for the crown delineation process, being indicative of crown centroids and boundaries, respectively. [9]Wang developed a marker-controlled watershed segmentation method on a 256- by 256-pixel CASI image of a commercially thinned trial forest and got a promising agreement between the automatic methods and manual delineation results [13].

## II. METHODOLOGY

Mathematical morphology is a tool widely used in very diverse image processing tasks such as feature detection, image segmentation and image denoising. In the context of remote sensing, it has been applied successfully to generate morphological features useful for the discrimination of objects in high spatial images [5]. The two fundamental operators in mathematical morphology are erosion and dilation. These operators are applied to an image with a set of known shapes, called the structuring elements (SEs). The erosion consists of finding where the SE fits the objects in the image. The dilation, which is dual to the erosion, shows where the SE hits the objects. From these basic operators, different combined operators can be constructed. The most common are *opening* and *closing*. An opening result in a new image where small bright objects (compared to their surroundings) are deleted. This means that they get assigned the gray-scale value of their surroundings. Dark objects are left unchanged. The dual operation of the opening is the closing. This operator reverses the interpretation of gray-scale values and thus removes small dark objects and leaves bright objects unchanged. Usually, these operators are applied using structural elements (SE) with different shapes and sizes such as disks and lines SEs. As the size of SE increases, objects are removed from the image.

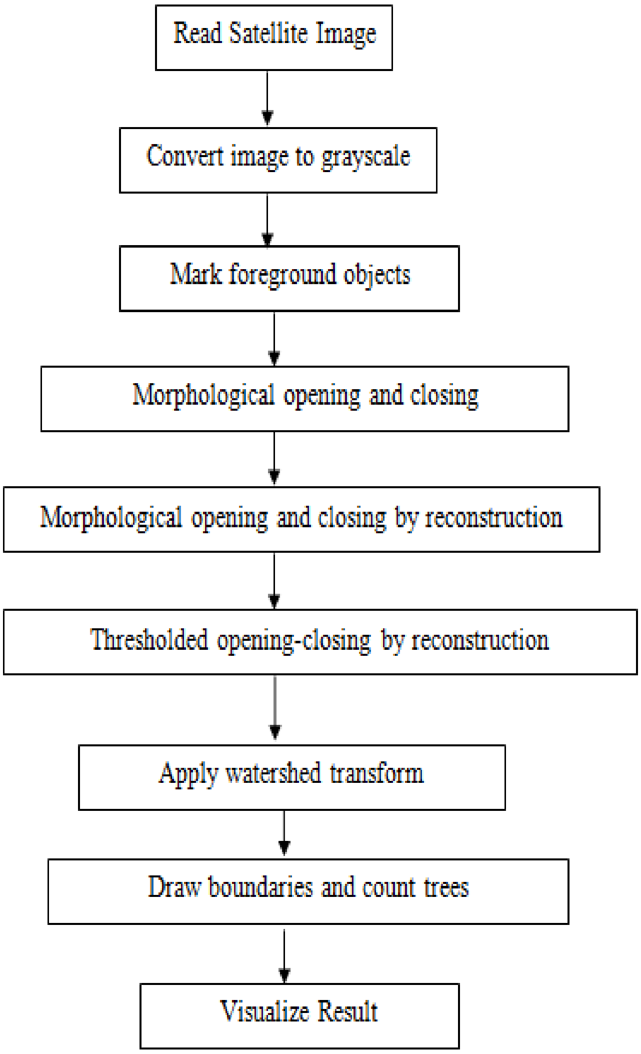


Fig 1: Flow chart of Tree Counting Algorithm

Fig 1 shows the flow chart of tree counting algorithm. First step is to read satellite image into MATLAB workspace and convert it to grayscale image since morphological operations are applied on grayscale images. Next step is to mark the foreground objects, which must be connected blobs of pixels inside each of the foreground objects. In this paper morphological techniques called "opening-by-reconstruction" and "closing-by-reconstruction" to "clean" up the image are used. These operations will create flat maxima inside each object. Opening is erosion followed by dilation, while opening-by-reconstruction is erosion followed by a morphological reconstruction. First compute opening followed by opening-by-reconstruction. Following the opening with a closing can remove the dark spots and stem marks. Reconstruction-based opening and closing are more effective than standard opening and closing at removing small blemishes without affecting the overall shapes of the objects. To obtain background markers threshold opening-closing by reconstruction. Separating touching objects in an image is one of the more difficult image processing operations. The watershed transform is often applied to this problem. The watershed transform finds "catchment basins" and "watershed ridge lines" in an image by treating it as a surface where light pixels are high and dark pixels are low. Watershed transform without image pre-processing steps like morphological operations leads to over segmentation so in this algorithm first morphological operations are applied to the input image then watershed segmentation is used. Using Moore-Neighbor tracing algorithm modified by Jacob's stopping criteria is used to count trees [16] .

 

## III. RESULTS

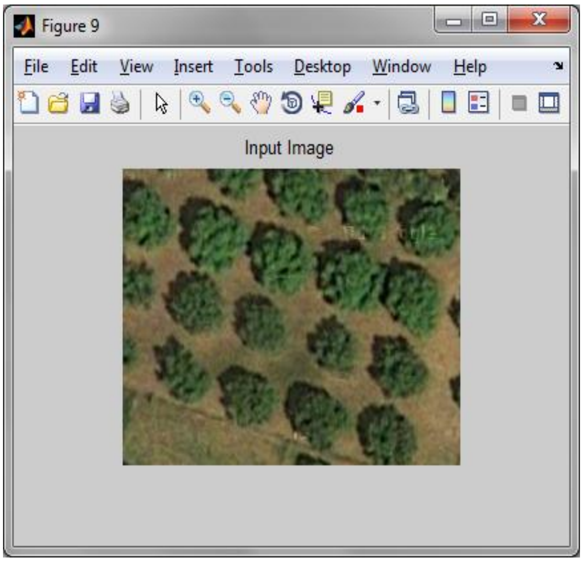


Fig 2: Input Satellite Image

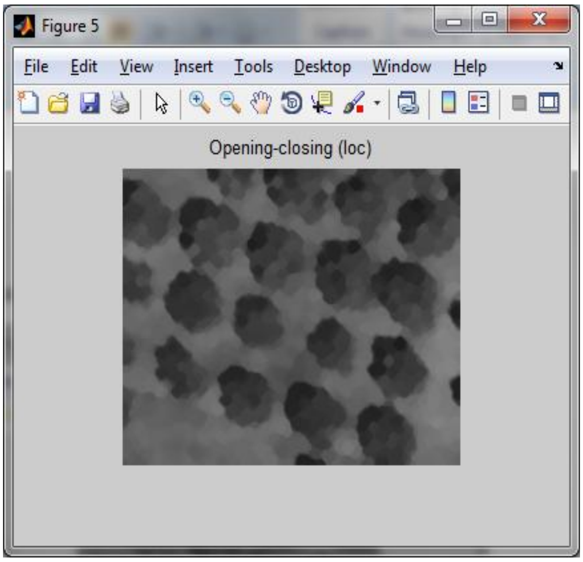


Fig 3: Opening-Closing

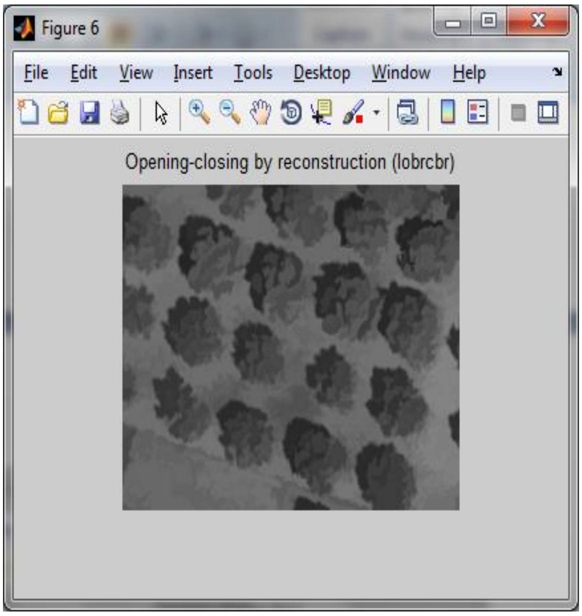


Fig 4: Opening-Closing by reconstruction

 

Opening-closing by reconstruction removes features smaller than the structuring element, without altering the shape; reconstruct connected components from the preserved features; Opening by reconstruction removes unconnected light features; Closing by reconstruction removes unconnected dark features. Next step is to threshold opening-closing by reconstruction, then fill holes. Watershed transform is applied to delineate touching tree crowns. Drawing boundaries and counting gives exact tree count. The tree count for given satellite image is 20. The result varies when the structuring element disk diameter is changed. Choose structuring element according to the structure of image.

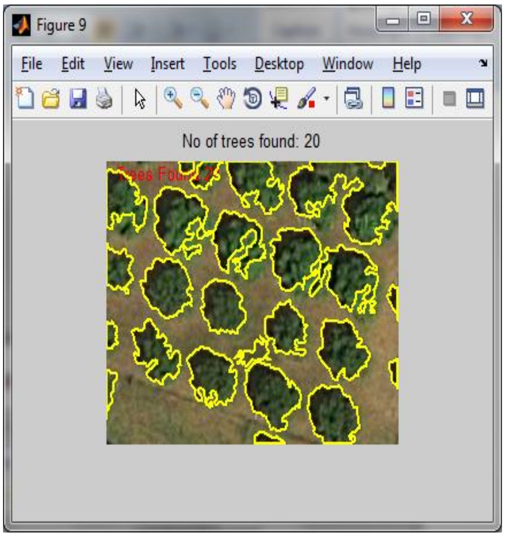


Figure 5: Final Output Image

Another image is taken with touching tree crowns. Tree counting algorithm is applied to this image. The algorithm gave good result with delineating touching crowns. Number of trees found in the image is 105. By manual interpretation there are around 95 trees. The algorithm is tested for different images with tree count from 2 to 100.

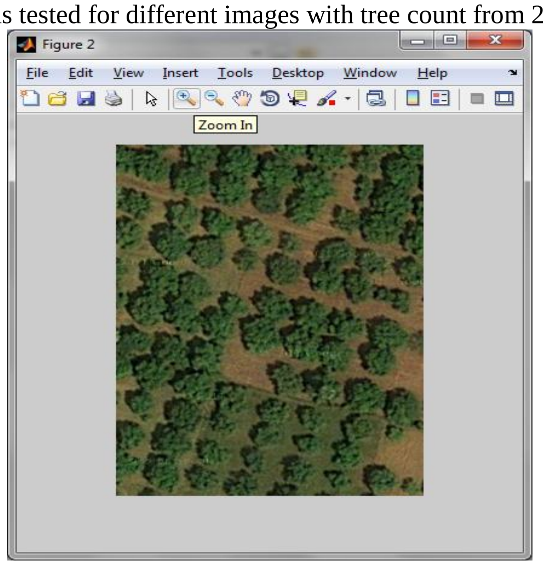


Fig 6: Input image2

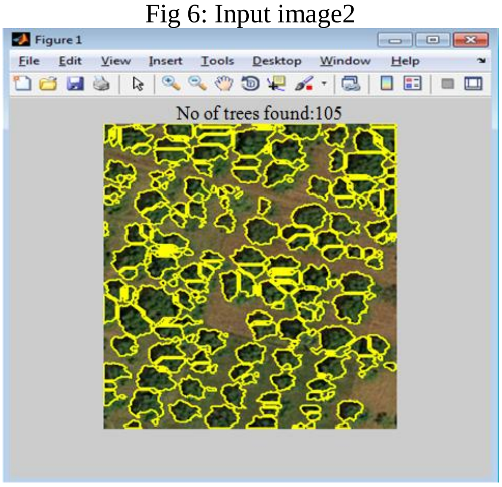


Fig 7: Output for image2

When Satellite image of urban area is taken then taking only green area and after applying median filter noise is removed.Then, above algorithm is implemented the resuts are shown in Fig 8 and 9.

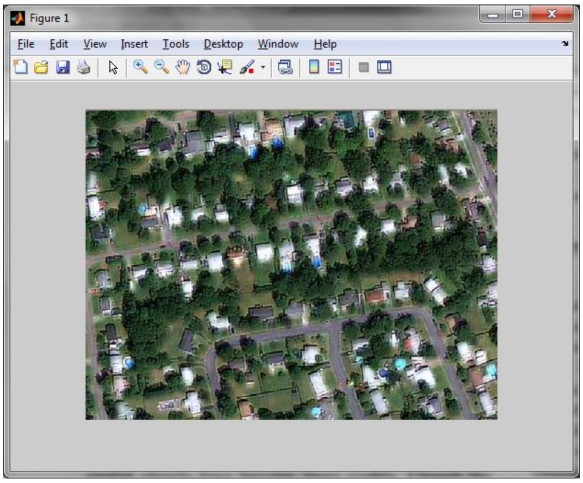


Fig 8: Trees in an urban area

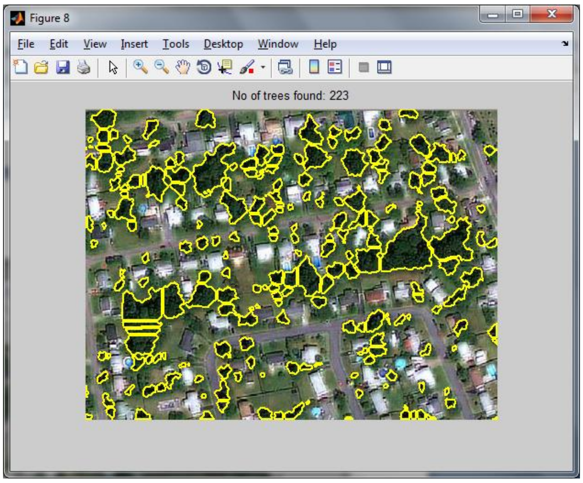


Fig 9: Tree Count in urban area

## IV. CONCLUSIONS

Tree counting in a specific geographical area is a complicated process. With evolution of satellite images it is made easy. Tree Counting implemented using morphological opening and closing does not yield good result. So, Tree Counting by morphological opening and closing by reconstruction and watershed transform to delineate overlapping tree crowns is implemented.

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