

A METHOD FOR DEVELOPING TREE POSITIONING MAP, ESTIMATING TREE COUNTS AND CROWN AREA RATIO

FIELD OF INVENTION

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The invention relates to a method for determining tree position in a plantation. More particularly, the invention relates to a method for determining positions, count and crown area ratio of the trees in the plantation with improved accuracy.

10 BACKGROUND OF THE INVENTION

The tree plantation is cultivated for harvesting purpose. Monitoring is a process to check the trees in plantations for planning next cycle of harvesting and plantation work. The huge area of the plantation may need many workers and time to finish the
15 monitoring process. Therefore, determination of the trees by means of image processing can be used to determine position, count and its coverage in an aerial image captured by unmanned vehicles. For example, determination of tree position is used in agricultural industry to determine the presence and coverage of tree for next cycle of tree plantation and harvesting.

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Over the years, various methods for detecting weed were developed. For instance, United States of America Granted Patent Number US10614562B2 discloses an inventory, growth, and risk prediction using image processing may include receiving a plurality of images captured by a vehicle during movement of the vehicle along a
25 vehicle path. The images may include a plurality of objects. The images may be pre-processed for feature extraction. A plurality of features of the objects may be extracted from the pre-processed images by using a combination of computer vision techniques. A parameter related to the objects may be determined from the extracted features. A spatial density model may be generated, based on the determined parameter and the

extracted features, to provide a visual indication of density of distribution of the objects related to a portion of the images, and/or to provide an alert corresponding to the objects related to the portion of the images

- 5 The aforementioned methods may not provide sufficient accuracy for determining tree position, thereby inaccurately estimating the tree coverage. Therefore, it would be desirable to provide a method for determining position, count, and crown area ratio of the tree with improved accuracy. This invention provides a solution to the problem.

10 SUMMARY OF INVENTION

- The present invention provides a method for determining position, count and crown area ratio of trees from an acquired image, the method comprising the steps of: converting the acquired image from a Red, Green, and Blue, RGB image into Hue
- 15 Saturation Value, HSV image; converting the HSV image into a binary image using a thresholding algorithm; locating centroid of each contour within the binary image using a distance transform technique; segmenting the contours using a watershed segmentation algorithm, wherein each contour represents an individual tree; calculating contour area of the segmented contours; removing contours with area size that exceeds
 - 20 a predefined range; and determining the position, count and crown area ratio of the tree through the remaining contours, characterized in that the centroids of each contour are located by the steps of: determining distance of each pixel within the contour to a nearest background pixel by applying Euclidean distance transform algorithm; and finding local maxima of each contour using a maximum filter.

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Preferably, the method may further comprise the step of inputting a plurality of parameters related to threshold required for binary image generation, contour area maximum and minimum sizes, minimum distance between two contours, and size of the grid.

Preferably, the method may further comprise the step of labelling each segmented contour before calculating the contour area of each segmented contour.

- 5 Preferably, the method may further comprise the steps of: applying the grids of a predefined size on the binary image; calculating crown area ratio for individual grid; estimating tree count within individual grid; and generating tree positioning map for visualization of tree location.
- 10 Preferably, the method may further comprise the step of validating the accuracy of the segmented contours using a validation technique. The validation technique may comprise the steps of: applying ground truth markers to differentiate trees from a boundary box; and determining if an intersection over union value exceed a predetermined value.
- 15 Preferably, the method may further comprise the step of isolating the segmented contour from overlapping contours if the intersection over union value exceeded the predetermined value.
- 20 One skilled in the art will readily appreciate that the invention is well adapted to carry out the objects and obtain the ends and advantages mentioned, as well as those inherent therein. The embodiments described herein are not intended as limitations on the scope of the invention.

25 BRIEF DESCRIPTION OF THE DRAWINGS

For the purpose of facilitating an understanding of the invention, there is illustrated in the accompanying drawing the preferred embodiments from an inspection of which when considered in connection with the following description, the invention, its

construction and operation and many of its advantages would be readily understood and appreciated.

5 Figs. 1a & 1b is a flow diagram illustrating a method for determining tree positions, estimating tree count and crown area ratio of the trees in a plantation.

Fig. 2 illustrates converted binary image using thresholding algorithm.

10 Fig. 3 illustrates estimate of crown area for applying grids.

Fig. 4 illustrates overlay of individual grids for trees during visualization.

Fig. 5 illustrates tree count for visualization.

15 DETAILED DESCRIPTION OF THE INVENTION

The invention will now be described in greater detail, by way of example, with reference to the drawings.

20 Referring to Figs. 1a & 1b, a method determining position, count, and crown area ratio of the trees in a plantation is illustrated therein. In step **110**, an image of the plantation is acquired. The acquired image can be a still image or a frame of a video of the plantation field. Preferably, the acquired image is an aerial image that represents top view of the plantation field taken by an image acquisition module such as a camera
 25 mounted on a drone, satellite, or closed-circuit television (CCTV). The acquired image is preferably a coloured image such as a Red, Green, and Blue (RGB) image in 2-dimensional plane or in a 3 spatial dimensional data.

In step **120**, the acquired image is preferably converted into a hue, saturation, value

(HSV) image. Preferably, HSV colour models are used in particular for selecting precise colours for tree crowns in the plantation. In step **130**, user inputs a plurality of parameters. Alternatively, the parameters can be generated automatically by training models. The parameters may include but are limited to threshold required for binary image generation, contour area maximum and minimum sizes, minimum distance between two contours, and size of the grid. In step **140**, convert the HSV image into a binary image as shown in **Fig. 2** using a threshold algorithm to separate each pixel in the image as tree pixels and background pixels. Preferably, threshold ranges are determined using techniques such as Otsu thresholding, adaptive thresholding, in-range thresholding and others from open-source computer vision online packages. Next, locate centroid of each contour within the binary image using a distance transform technique. In step **150**, determine distance of each pixel within the contour to nearest background pixel. Preferably, Euclidean distance transform algorithm is applied. In step **160**, calculate local maxima of each contour using a maximum filter. Steps **150 & 160** dilate the original image and merges neighbouring local maxima closer than the size of the dilation. Locations where the original image is equal to the dilated image are returned as local maxima. Minimum distances between peaks are used to find the local maxima, which is also used as proxy to trees/plantation.

In step **170**, segment the contours using a watershed segmentation algorithm. Preferably, the watershed segmentation algorithm is used to segment trees from the background. From local maximum, the watershed segmentation algorithm treats pixel values as a local topography (elevation). The algorithm floods basins from markers until basins attributed to different markers meet on watershed lines. Preferably, the local maxima from the Euclidean distance transform are chosen as the markers. In other words, the inverse of the Euclidean distance transform is used as the local topography to flood the basins. In step **180**, label each segmented contour and further calculate contour area of the labelled contours. Preferably, each pixels takes a unique label representing different instances of trees or background. Contour for each label is

determined and further used to calculate the contour area using georeferenced contours. In step **190**, remove the contours with contour area size that exceeds a predefined range.

Alternatively, a validation method can be applied to validate the accuracy of the determined contours. Preferably, the validation techniques may include but not limited to Intersection over Union (IOU) of the generated tree contour and ground truth to validate the performance of the tree segmentation results. By way of example, the IOU is computed according to Equation 1.

Equation 1:

$$IOU = \frac{\text{Area of intersection of generated contours and ground truth}}{\text{Area of intersection of generated contours and ground truth}}$$

In step **200**, applying ground truth markers to differentiate trees from a boundary box. In step **210**, determine if the intersection over union value computed from Equation 1 exceeded a predetermined threshold. In step **220**, isolate the segmented contour if its intersection over union value exceeded the predetermined threshold. The predetermined threshold is preferably within a range of 0.4 to 0.6. Once the intersection over union value condition is met, contours with trees will be isolated from each other and the background.

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In step **230**, apply grids on the binary image. Preferably, grids of predefined size are applied on the binary image based on the user inputted value as shown in Fig. 4. In steps **240** to **260**, calculate the position, count and crown area ratio of the trees within individual grid. Preferably, a tree positioning map can be generated based on the segmented contour areas for visualization of the tree location.

By way of example, the crown area ratio is computed according to Equation 2.

Equation 2:

$$\text{Crown Area Ratio (CAR)} = \frac{\text{Area of foreground (Tree pixels)}}{\text{Grid Area}} \times 100\%$$

Preferably, calculating the crown area ratio in the grid format enables better spatial visualization of the growth profile of trees within the planted area. The crown area ratio
 5 for individual grids and tree count within the grids are used as the outputs from the overlap of segmented image and grids generated from the binary image. For example, calculating the number of trees within the grid can estimate the mortality ratio of trees within a location given at a certain snapshot of time. Collection of these data at specific frequency over a time period allows a time series analysis of tree mortality, can be
 10 further used for purposes of reducing tree mortality from spatial, soil, tree genetics, climate and other perspective.

The present disclosure includes as contained in the appended claims, as well as that of the foregoing description. Although this invention has been described in its preferred
 15 form with a degree of particularity, it is understood that the present disclosure of the preferred form has been made only by way of example and that numerous changes in the details of construction and the combination and arrangements of parts may be resorted to without departing from the scope of the invention.

CLAIMS

1. A method for determining position, count and crown area ratio of trees from an acquired image, the method comprising the steps of:
 - 5 converting (120) the acquired image from a Red, Green, and Blue, RGB image into Hue Saturation Value, HSV image;
 converting (140) the HSV image into a binary image using a thresholding algorithm;
 locating centroid of each contour within the binary image using a distance transform technique;
 - 10 segmenting (170) the contours using a watershed segmentation algorithm, wherein each contour represents an individual tree;
 calculating (180) contour area of the segmented contours;
 removing (190) contours with area size that exceeds a predefined range; and
 determining the position, count and crown area ratio of the tree through the remaining
 - 15 contours,
 characterized in that the centroids of each contour are located by the steps of:
 determining (150) distance of each pixel within the contour to a nearest background pixel by applying Euclidean distance transform algorithm; and,
 finding (160) local maxima of each contour.
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2. The method according to claim 1, further comprising the step of inputting (130) a plurality of parameters related to threshold required for binary image generation, contour area maximum and minimum sizes, minimum distance between two contours, and size of the grid.
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3. The method according to claim 1, further comprising the step of labelling each segmented contour before calculating the contour area of each segmented contour.

4. The method according to claim 1, further comprising the steps of:
applying (230) the grids of a predefined size on the binary image;
calculating (240) crown area ratio for individual grid;
estimating (250) tree count within individual grid; and
- 5 generating (260) tree positioning map for visualization of tree location.
5. The method according to claim 1, further comprising the step of validating the accuracy of the segmented contours using a validation technique.
- 10 6. The method according to claim 5, wherein the validation technique comprises the steps of:
applying (200) ground truth markers to differentiate trees from a boundary box; and
determining (210) if an intersection over union value exceed a predetermined value.
- 15 7. The method according to claim 6, further comprising the step of isolating (220) the segmented contour from overlapping contours if the intersection over union value exceeded the predetermined value.