A METHOD FOR DETECTING WEED IN PLANTATION

FIELD OF INVENTION

The invention relates to a method for detecting weed. More particularly, the invention relates to a method for detecting weed with improved accuracy.

BACKGROUND OF THE INVENTION

Weed detection by means of image processing can be used to detect weed and its coverage from other plant species or objects in an image. For example, weed detection is used in agricultural industry to detect presence and coverage of weed. The presence of weed can adversely affect places such as plantation fields and gardens, where specific plantation is cultivated for aesthetic or harvesting purpose. Particularly, the presence of weed at the aforementioned places can result in competition with the plantation for resources such as sunlight, soil nutrients, water, and spaces which are essential for growth. Furthermore, propagation of weed provides shelter and food to sustain growth of pests that feed on or damage the plantation. Consequently, the presence of weed reduces quality and yield of the plantation. Hence, weed detection is important to maintain the quality and yield of the plantation.

Over the years, various methods for detecting weed were developed. For instance, Reddy *et al.* (International Journal of Engineering Technology, Management and Applied Sciences, Volume 5, Issue 4, Page 485 – 489) discloses a method to detect weed in an image. Firstly, HSV of the image are adjusted to separate green coloured portions (leaves of weed and crops) from the image. Then, edge detection is applied to obtain boundaries of the weed. Subsequently, the image after the edge detection is converted into a gray image and subjected to thresholding process to create a binary image. The binary image is further processed to detect weed. Additionally, China Patent

No. CN108564021B discloses a method for extracting desert vegetation coverage. Firstly, digital photos of desert vegetation are provided by a camera. Secondly, colour space of the photos are converted from RGB into HSV. Then, desert vegetation extraction characteristic indexes is calculated based on S and V, and desert vegetation distribution areas are distinguished by a threshold segmentation method to generate a binary map. Lastly, percentage of the vegetation pixel number in the total number of the photos are calculated based on the vegetation pixel number of the desert area.

The aforementioned methods may not provide sufficient accuracy for detecting weed, thereby inaccurately estimating the weed coverage. Therefore, it would be desirable to provide a method for detecting weed with improved accuracy. This invention provides a solution to the problem.

SUMMARY OF INVENTION

One objective of the invention is to provide a method for detecting weed in an image with improved accuracy via image processing.

In a first aspect of the invention, there is provided a method for detecting weed from an acquired image, the method comprising the steps of converting the acquired image into a colour space image and a vegetation index image; combining properties of the colour space image and the vegetation index image to generate a processed image; and outlining areas that represent the existence of the weed from the processed image via an image processing algorithm.

Preferably, the colour space image is generated based on a hue, saturation, value (HSV) model.

Preferably, the vegetation index image is generated based on Visible Atmospherically

Resistant Index (VARI).

Preferably, the processed image is generated by the steps of converting the colour space image and the vegetation index image respectively into a first binary image based on a set of first threshold values and a second binary image based on a set of second threshold values; and combining the first and second binary images using bitwise operations.

Preferably, the image processing algorithm comprises the steps of labelling areas representing plantation and the weed as foreground and areas representing object other than the plantation and the weed as background in the processed image; contouring the areas representing the plantation and the weed by connecting the areas labelled as foreground via connected components kernels; georeferencing the contoured areas using a projected coordinate system, whereby pixel units of the contoured areas are converted to distance units; and filtering the georeferenced contoured areas based on a third threshold value to remove undesired objects.

In a second aspect of the invention, the method for detecting weed from an acquired image further comprising the step of determining accuracy of the weed detection.

Preferably, the accuracy determination comprises the steps of computing a weed detection accuracy ratio based on the areas that represent the existence of the weed and a ground truth data; and determining if the weed detection accuracy ratio is lower than a fourth threshold value.

Preferably, the accuracy determination further comprising the steps of reiterating the steps as claimed in claim 1 with adjusted parameters; and further determining the accuracy of the weed detection obtained from the reiteration process until the reiterated accuracy exceeds the fourth threshold value.

In a third aspect of the invention, the method for detecting weed from an acquired image further comprising the steps of generating a spatial map to indicate areas that represent the existence of the weed based on the filtered contoured area.

Preferably, the method for detecting weed from an acquired image further comprising the steps of determining a grid weed ratio from the filtered contoured areas and generating an alert based on a fifth threshold value.

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.

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.

Fig. 1 is a flow diagram illustrating a method for detecting weed.

Fig. 2 is a first binary image generated by thresholding a HSV colour space image based on a set of first threshold values.

Fig. 3 is a second binary image generated by thresholding a VARI image based on a set of second threshold values.

Fig. 4 is a binary image generated by combining the first and second binary images using “AND” bitwise operation.

Fig. 5 is a binary image generated by combining the first and the secondary binary images using “OR” bitwise operation.

Fig. 6 is an image of filtered contoured area generated from the binary image obtained from “AND” bitwise operation.

Fig. 7 is an image of filtered contoured area generated from the binary image obtained from “OR” bitwise operation.

Fig. 8 is an image processed from ground truth data.

DETAILED DESCRIPTION OF THE INVENTION

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

Referring to Fig. 1, a method for detecting weed from an acquired image is illustrated therein. The term “weed” herein refers to a plant that is undesirable in a particular location. The weed can include but not limited to stray grass and flower. Preferably, the method in the present invention can be used to detect the weed from the plantation and other background objects. The plantation can include but not limited to *Eucalyptus*, *Acacia*, and oil palm. The acquired image can be a still image or a frame of a video of a 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 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 step **101**, the acquired image is preferably converted into a colour space image and a vegetation index image. Preferably, the colour space image is generated based on hue, saturation, value (HSV) model, whereas the vegetation index image is generated based on Visible Atmospherically Resistant Index (VARI) according to Equation 1. Alternatively, other colour space models such as L*a*b* can be used to generate the colour space image. Alternatively, the vegetation index image is generated based on Green-Red Ratio Vegetation Index (GRVI), Green Leaf Index, or Modified Green-Red Vegetation Index.

Equation 1:

$$VARI = \frac{(Green - Red)}{(Green + Red - Blue)}$$

In the preferred embodiment of the invention, properties of the colour space image and the vegetation index image are combined to generate a processed image. The colour space image and the vegetation index image are preferably converted into a first and a second binary images, respectively. The converted colour space image and vegetation index image are shown in Fig. 2 and Fig. 3, respectively. Such conversion simplifies data in the colour space image and vegetation image, thereby improving efficiency of image processing for the subsequent steps. Preferably, in step **102**, the colour space image is converted into the first binary image based on a set of first threshold values, whereas the vegetation index image is converted into the second binary image based on a set of second threshold values. More preferably, the set of first threshold values is based on HSV model ranges, whereas the set of second threshold values is based on VARI ranges. In step **103**, the properties of the first and second binary images are preferably combined using bitwise operations to generate the processed image, as shown in Fig. 4 and Fig. 5. More preferably, the bitwise operations use bitwise operators such as “AND” or “OR”. Advantageously, the first and second binary images are combined to generate another binary image, thereby improving the accuracy of the combined binary image.

In the preferred embodiment of the invention, areas that represent the existence of weed are outlined from the processed image in the form of contour via an image processing algorithm. The image processing algorithm describe herein comprises four steps, starting by labelling areas representing the plantation and the weed as foreground and areas representing object other than the plantation and the weed as background in the processed image, then contouring the areas representing the plantation and the weed by connecting the areas labelled as foreground via connected components kernels and georeferencing the contoured areas using a projected coordinate system, whereby pixel units of the contoured areas are converted to distance units, and lastly filtering the georeferenced contoured areas based on a third threshold value to remove undesired objects. Preferably, in step **104**, the image processing algorithm firstly labels areas representing the plantation and the weed as foreground and areas representing object other than the plantation and the weed as background in the processed image. By way of example, the object other than the plantation and the weed may include but is not limited to soil, rock, agricultural tool, dried leaf, withered agricultural crop, or any combinations thereof. Subsequently, in step **105**, the image processing algorithm preferably contours the areas representing the plantation and the weed by connecting the areas labelled as foreground via connected component kernels. Preferably, the connected component kernels is a 4-connected component or an 8-connected component kernel. Then, the image processing algorithm georeferences the contoured areas using a projected coordinate system to convert pixel units of the contoured areas to distance units such that the area representing the plantation and the weed can be measured. In step **106**, the image processing algorithm preferably filters the georeferenced contoured areas via a contour area thresholding operation based on a third threshold value to remove undesired objects. Preferably, the georeferenced contoured areas are filtered to remove areas representing tree crowns of the plantation therefrom such that areas representing the weed can be identified. Fig. 6 and Fig. 7 show the filtered contoured area based on combination of the HSV colour space and the VARI images using “AND” and “OR” bitwise operations, respectively.

When necessary, the method of the invention provides a step of determining accuracy of the weed detection to ensure reliability of weed detection output. Preferably, the accuracy determination is performed by computing a weed detection accuracy ratio in step **107** based on the areas that represent the existence of the weed obtained from the image processing algorithm and a ground truth data. In step **108**, the ground truth is preferably a data obtained from direct examination of the areas that represent the existence of the weed in the plantation field. In step **109**, the areas that represent the existence of the weed identified on the ground truth data is preferably translated into spatial polygons via a geographic information system (GIS) processing software. The image processed from ground truth data is shown in Figure 8. This allows the spatial polygons to be recorded in a projected coordinate system such that the areas that represent the existence of the weed identified can be calculated. By way of example, the weed detection accuracy ratio is computed according to Equation 2.

Equation 2:

$$Weed\ detection\ accuracy\ ratio = \frac{overlapping\ area\ between\ filtered\ contoured\ area\ and\ ground\ truth}{combined\ area\ of filtered\ contoured\ area\ and\ ground\ truth}$$

Subsequently, the weed detection accuracy ratio is determined if it is lower than a fourth threshold value. The fourth threshold value herein refers to a predefined weed detection accuracy ratio that indicates a minimum accuracy requirement for weed detection, whereby a weed detection accuracy ratio lower than the predefined weed detection accuracy ratio indicates an inaccurate weed detection. Preferably, step **102-109** are performed during model training phase to fine tune parameters such as the sets of first and second threshold values and optimum bitwise operation. Subsequently, the fine-tuned parameters will be used for weed detection.

Preferably, when the computed weed detection accuracy ratio is lower than the fourth threshold value, as identified in step **110**, the step of combining the properties of the colour space image and the vegetation index image and the step of outlining areas that

represent the existence of the weed from the processed image can be reiterated with adjusted parameters, as depicted in step **111**. By way of example, the colour space image, the vegetation index image, or both can be converted into their respective binary images based on different sets of threshold values. Thereafter, the weed detection accuracy ratio is further determined. Preferably, the reiteration process can be repeated until the weed detection accuracy ratio exceeds the fourth threshold value in order to obtain the optimum parameters for weed detection. This may be important when the method is firstly used for weed detection in a different environment with different conditions such as climates, seasons, and types of plantation and weed in which existing parameters may not be appropriate.

In step **112**, a spatial map is preferably generated based on the filtered contoured areas to indicate areas that represent the existence of the weed. Preferably, the spatial map is in the form of grids and the filtered contoured areas indicated on the spatial map depicts the coverage of the weed within a grid. Preferably, a grid weed ratio is determined from the filtered contoured area and grid area according to Equation 3.

Equation 3:

$$Grid\ weed\ ratio = \frac{Filtered\ contoured\ areas\ that\ represent\ weed\ within\ a\ grid}{Grid\ area}$$

Subsequently, in step **113**, an alert can be generated based on a fifth threshold value. For example, a higher grid weed ratio than the fifth threshold value indicates a severe weed overrun in the indicated area. Preferably, the alerts can be generated on the spatial map such that appropriate action can be taken. In an exemplary embodiment of the invention, the alert is generated in the form of colour code within the grids on the spatial map, wherein different colour codes represent different level of severity and actions to be taken. Advantageously, the method in the invention provides an automated weed detection with minimal user input.

EXAMPLE

The following non-limiting example has been carried out to illustrate the preferred embodiments of the invention.

Example 1

Weed detection accuracy ratios obtained from different methods are shown in Table 1. Accordingly, the weed detection accuracy ratio obtained from the method described in the invention is higher than those obtained using HSV model or VARI independently.

Table 1: Weed detection accuracy ratios obtained from independent HSV model, independent VARI, and method according to the invention.

Method	Weed Detection Accuracy Ratio (%)
HSV only	48
VARI only	50
HSV + VARI (“OR” bitwise operation)	60

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 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 detecting weed from an acquired image, the method comprising the steps of:

converting the acquired image into a colour space image and a vegetation index image;

combining properties of the colour space image and the vegetation index image to generate a processed image; and

outlining areas that represent the existence of the weed from the processed image via an image processing algorithm.

2. The method according to claim 1, wherein the colour space image is generated based on a hue, saturation, value (HSV) model.

3. The method according to claim 1, wherein the vegetation index image is generated based on Visible Atmospherically Resistant Index (VARI).

4. The method according to claim 1, wherein the processed image is generated by the steps of:

converting the colour space image and the vegetation index image respectively into a first binary image based on a set of first threshold values and a second binary image based on a set of second threshold values; and

combining the first and second binary images using bitwise operations.

5. The method according to claim 1, wherein the image processing algorithm comprises the steps of:

labelling areas representing plantation and the weed as foreground and areas representing object other than the plantation and the weed as background in the processed image;

contouring the areas representing the plantation and the weed by connecting the areas labelled as foreground via connected components kernels;

georeferencing the contoured areas using a projected coordinate system, whereby pixel units of the contoured areas are converted to distance units; and

filtering the georeferenced contoured areas based on a third threshold value to remove undesired objects.

6. The method according to any of claims 1 to 5 further comprising the step of determining accuracy of the weed detection.

7. The method according to claim 6, wherein the accuracy determination comprises the steps of:

computing a weed detection accuracy ratio based on the areas that represent the existence of the weed and a ground truth data; and

determining if the weed detection accuracy ratio is lower than a fourth threshold value.

8. The method according to claim 7 further comprising the steps of:

reiterating the steps as claimed in claim 1 with adjusted parameters; and

further determining the accuracy of the weed detection obtained from the reiteration process until the reiterated accuracy exceeds the fourth threshold value.

9. The method according to claims 5 or 8 further comprising a step of generating a spatial map based on the filtered contoured areas to indicate areas that represent the existence of the weed.

10. The method according to claim 9 further comprising a step of determining a grid weed ratio from the filtered contoured areas and generating an alert based on a fifth threshold value.