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Weed Classification in Maize Field Using Gabor Filter

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ABSTRACT : Weed control is one of the most important and also expensive laborious tasks in crop production. The proposed algorithm will have the ability to holistically classify weed and crop in image processing. Firstly, Otsu's method is an image processing technique that can be used to convert a gray scale image into a purely binary image. Secondly, Gabor Filter is a linear filter used for edge detection and to obtain more accuracy. Finally, the various different kinds of weed images would be processed individually and classified as weed or crop using PCA. We use PCA, in case of discrepancy between weed and crop to further classify the data. The combination of Otsu method and the PCA not only enable us to detect weed in crop but also classify this weed from crop.

KEYWORDS: Gabor filter, Image processing, Image segmentation, Otsu's method, Principle Component Analysis.

I. INTRODUCTION

It is estimated that around 1.5 billion dollars is spent every year for weed control activities. Weeds are controlled by applying herbicides or they can be removed by mechanical instruments. Nowadays, since mechanical ways are not efficient and they are laborious, using herbicides are more common in cultivating; but most herbicides are applied uniformly although weeds are not distributed uniformly. Overusing the herbicides causes the cost of agricultural production to be increased, and also it results in dangerous damages for the environment. Based on the mentioned problems, several researches have been investigated to facilitate the cultivation operation by means of developing automatic weeding machines; furthermore, by Site-specific management of the weeds the costs of cultivation and environmental damages will be reduced. Site-specific managements of the weeds in the field need accurate discrimination between the crop and the weeds. Several research projects have been conducted to recognize weeds in crops via employing machine vision technology. Plant shape, texture, and color have all been investigated as possible image features for distinguishing weeds from crop plants.

II. RELATED WORK

There are basic 4 techniques used to detect the crop and weed in the agriculture field.

A. Biological Morphology Based Technique

In biological morphological shape and size features are extracted. Shape features like, major axis, areas, minor axis, aspect ratio, width are used for detection of plant. Hidden features are also found with the help of biological morphological technique. Hong Y. Jeon Lei F. Tian used the excessive green colure algorithm for segmentation of soil and vegetation, after that median filtering for removing the noise, morphological features and calculation of statistical threshold value. Using this, they got 72.6% of precision. Seven shape features for detection of crop and weed is used by S. Kiani, A. Jafari but this is limited to only for corn crop and they got the accuracy 98.9%.

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B. Plant Reflectance Based Technique

Spectral reflectance technique is used for plant species identification. Spectrometer is necessary to record spectral reflectance parameter but cost is higher than the common former can offered. Various types of spectral reflectance parameter is used like for vegetation indices, to measure crop properties in the visible spectrum typically ratios of broadband reflectance values are used. The features like, variance of the near infrared spectrum, skewness, average gives the high level of success in color segmentation. Piron et al got 72% of accuracy in their proposed system for detection of weed in carrot rows.

C. Visual Texture Based technique

In this technique texture features of the image such as, energy, entropy, contrast, homogeneity, and inertia are used for detection of plant. By using the support vector algorithm and extracting the texture features energy, entropy, inertia, homogeneity, contrast and relegated got the 93% of precision. Kiani S, verified that different ANN gives different accuracies with five texture features energy, contrast, homogeneity, inertia, entropy as a input to the ANN. Gabor wavelet combined with PCA algorithm got 90.5% of precision. In this paper wavelet transform Db4 is used for extracting the texture features of crop and weed images.

III. PROPOSED METHODOLOGY

In propose scheme, the crop area is taken by the image and apply Otsu thresholding method converted to binary image. Then the binary image is taken apply threshold level for weed area, based on the weed area weed plants are separated from the crop area. If the threshold value exceed apply PCA implementation to the image to retrieve the relevant image from the database.

1. IMAGE ACQUISITION AND SEGMENTATION

Once the image is captured in the RGB color model, the first step consists in the plant extraction or greenness image segmentation. A pixel where the predominant spectral component is the green is considered vegetation. In our images this assumption is acceptable due to the nature of the images and because they are acquired in the middle of maize fields where only soil, weed and crop plants are present. In order to discriminate between vegetation and no vegetation we have used color vegetation indices and extracted the Excess Green (ExG) using equation (2). The choice was made after comparing the following indices and to observe how plants were identified: ExG, excess green minus excess red index or ExGR as illustrated in equation (5).

2. COLOR SPACE NORMALISATION

Given an original input image in the RGB color space, the following normalization scheme was applied, this scheme is usually applied in agronomic image segmentation , and hence we obtain the normalized spectral r, g and b components ranging in [0,1] according to (1),

$$r = \frac{R}{R+G+B}, g = \frac{G}{R+G+B}, b = \frac{B}{R+G+B} \quad (1)$$

where R, G and B are the normalized RGB coordinates ranging from 0 to 1.

3. INDICES COMPUTATION

They are computed based on the following equations:

- (2) Excess green: $ExG = 2g - r - b$
- (3) Excess red: $ExR = 1.4r - g$
- (4) Excess blue: $ExB = 1.4b - g$
- (5) Excess green minus Excess red: $ExGR = Exg - ExR$

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4. OTSU'S METHOD

Otsu's method is an image processing technique that can be used to convert a grayscale image into a purely binary image by calculating a threshold to split pixels into two classes. More generally, Otsu's method can be used to split a histogram into two classes which minimizes the intra-class variance of the data contained within the class.

Otsu Algorithm

STEP 1: Compute histogram and probabilities of each intensity level

STEP 2: Set up the initial (0) and (0)

STEP 3: Step through all possible threshold $t = 1$ maximum intensity

(i) Update ω and μ

(ii) Compute $\sigma_b^2(t)$

STEP 4: Desired threshold corresponds to the maximum $\sigma_b^2(t)$.

Computation of Otsu Threshold

Otsu's thresholding method involves iterating through all the possible threshold values and calculating a measure of spread for the pixel levels each side of the threshold, i.e. the pixels that either falls in foreground or background. The aim is to find the threshold value where the sum of foreground and background spreads is at its minimum.

$$\sigma_{\omega}^2 = \omega_b \sigma_b^2 + \omega_f \sigma_f^2$$

Background and Foreground weight

Background weight $\omega_b = \sum_{i=1}^t p(i)$

Foreground weight $\omega_f = \sum_{i=t+1}^I p(i)$

Background and Foreground Mean

Background mean $\mu_b = \sum_{i=1}^t \frac{i p(i)}{\omega_b}$

Foreground mean $\mu_f = \sum_{i=t+1}^I \frac{i p(i)}{\omega_f}$

Background and Foreground Variance

Background variance $\sum_{i=1}^t [i - \mu_b]^2 \frac{p(i)}{\omega_b}$

Foreground variance $\sum_{i=t+1}^I [i - \mu_f]^2 \frac{p(i)}{\omega_f}$

5. GABOR FILTER

Gabor filter is a Gaussian kernel function modulated by a complex sinusoidal plane wave, defined as:

$$G(x, y) = \frac{f^2}{\pi \gamma n} \exp \left[-\frac{x'^2 + \gamma^2 y'^2}{2\sigma^2} \right] \exp (j2\pi f x' + \phi)$$

$$x' = x \cos \theta + y \sin \theta$$

$$y' = -x \sin \theta + y \cos \theta$$

Where f is the frequency of the sinusoidal factor, θ represents the, ϕ is the phase offset, σ is the standard deviation and γ is the spatial aspect ratio. Gabor wavelet filter employed on whole image to extract the features.

6. PRINCIPLE COMPONENT ANALYSIS (PCA)

PCA finds a linear projection of high dimensional data into a lower dimensional subspace such as the variance retained is maximized and the least square reconstruction error is minimized. The number of original variables is greater than or equal to the number of principal components. It is sensitive to the relative scaling of the original variables. PCA is a true eigenvector-based multivariate analysis algorithm.

PCA Algorithm

STEP1: Organize the data vector into column vector

STEP2: Compute the empirical mean (Me) along each column

STEP3: Subtract Me from data matrix S

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STEP4: Find the covariance matrix c of X

STEP5: Compute eigenvalue & eigenvector

STEP6: Sort them by decreasing eigenvalue

IV. EXPERIMENTAL RESULTS

STEP 1: The image is captured in the RGB color model. An image segmentation approach, based on vegetation index, is applied. A first image thresholding method identifies green parts (weeds/crop). Original images are captured in the color space RGB are transformed to gray images by applying the ExG vegetation index



Fig.(a). Image in RGB color model.

STEP 2: The second step consists in the plant extraction or greenness image segmentation. A pixel where the predominant spectral component is the green is considered vegetation. In our images this assumption is acceptable due to the nature of the images and because they are acquired in the middle of maize fields where only soil, weed and crop plants are present.

ExGR

Excess Green

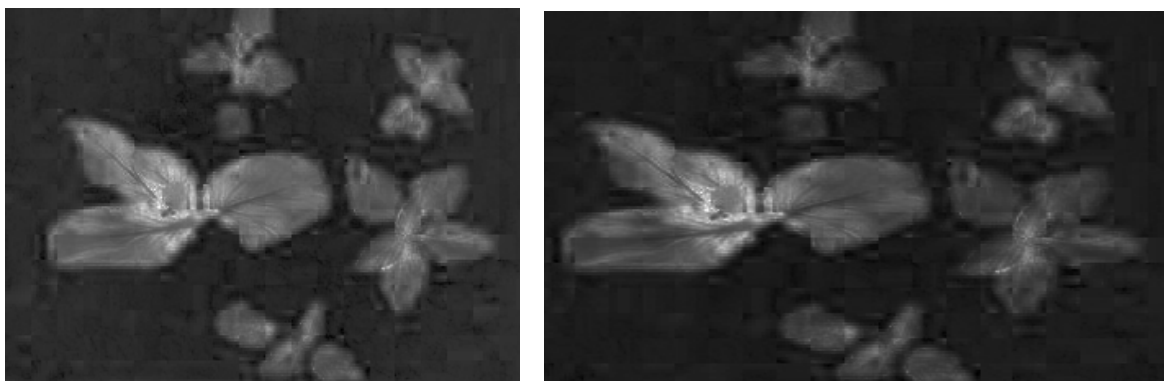


Fig.(b). Indices Computation.

STEP 3: To binarize the grey-scale image, a threshold value, which maximized the variance between the plant group and non-plant group pixels, was chosen using OTSU's method. Otsu's method can be used to split a histogram into two classes which minimizes the intra-class variance of the data contained within the class.

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Ostu Thresholding



Fig.(c). Converting RGB into binary image by otsu

STEP 4: Finally the combination of Otsu method and the PCA enable us to not only detect weed in crop rows but also classify this weed from crop. Based on the area crop and weed are separated, these images were then successfully processed to distinguish between crop and weed at a more detailed level.

Crop Area



Weed Area

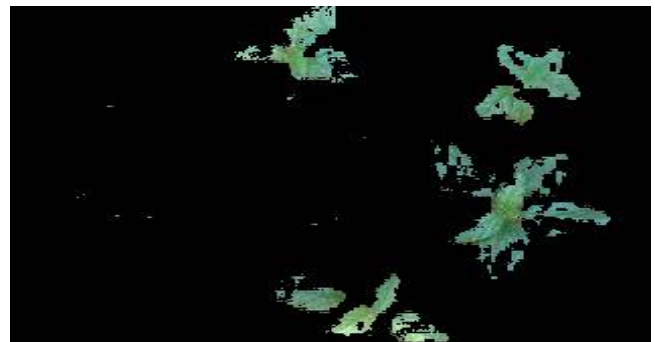
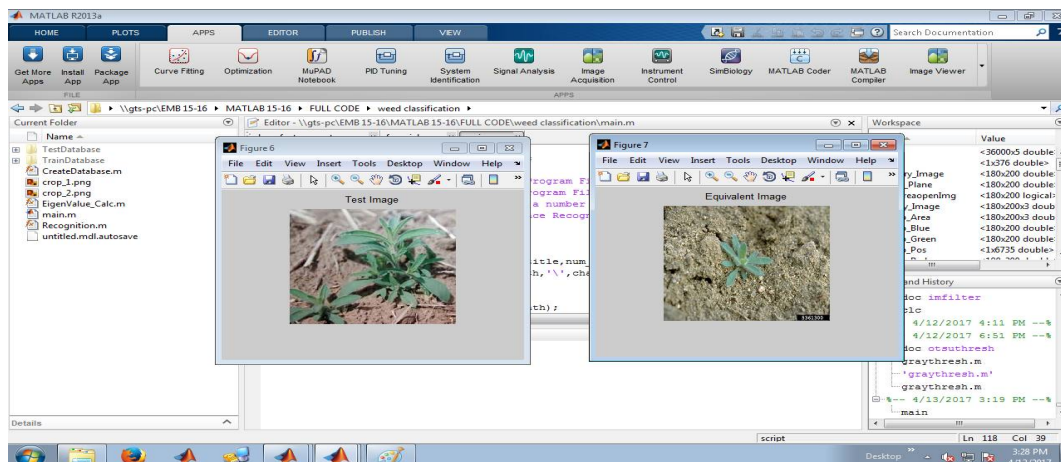


Fig.(d). Separation of crop and weed.

STEP 5: Further extrapolated using PCA algorithm to distinguish crops from weed in high density areas over the each crop row for the weed present in that crop row area. The low processing time for PCA will enable it for the instantaneous detection of the weed in the crop field.



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V. CONCLUSION

The method proposed is for crop detection in maize fields with high weeds pressure. Original images are captured in the color space RGB and transformed to gray images by applying the ExG vegetation index. After this transformation, a double thresholding Otsu approach allows to separate weeds and crops, then Gabor filter equation for various values is obtained and applied in the image in the respective pixels to obtain more accuracy in the separation of crop and weed and it is further extrapolated using PCA algorithm to distinguish crops from weed in high density areas over the each crop row for the weed present in that crop row area. The instantaneous detection of different types of plants in real-time scenario can find its application on various agriculture fields. The low processing time for PCA will enable it for the instantaneous detection of the weed in the crop field.

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