IMAGE PROCESSING IN AGRICULTURE

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ABSTRACT:

Image processing is a method to convert an image into digital form and perform some operations on it, in order to get an enhanced image or to extract some useful information from it.

PURPOSE OF IMAGE PROCESSING:

1. Visualization - Observe the objects that are not visible.

2. Image sharpening and restoration - To create a better image.

3. Image retrieval - Seek for the image of interest.

4. Measurement of pattern – Measures various objects in an image.

5. Image Recognition – Distinguish the objects in an image.

Image processing has been proved to be effective tool for analysis in various fields and applications.
Agriculture is the backbone of human sustenance on this world. Now a days with growing population we need the productivity of the agriculture to be increased a lot to meet the demands. In olden days they used natural methods to increase the productivity, such as using the cow dung as a fertilizer in the fields. That resulted increase in the productivity enough to meet the requirements of the population. But later people started thinking of earning more profits by getting more outcome. So, there came a revolution called "Green Revolution". After this period usage of deadly poisons as herbicides has increased to a drastic level. By doing so we got success in increasing the productivity but we have forgot damage done to the environment, which will arise a doubt in our sustenance on this beautiful earth. This paper intends to focus on the survey of application of image processing in agriculture field such as imaging techniques, weed detection and fruit grading, to reduce the usage of herbicides. The analysis of the parameters has proved to be accurate and less time consuming as compared to traditional methods. Application of image processing can improve decision making for vegetation measurement, irrigation, fruit sorting, etc.

In this paper we implemented image processing using MATLAB to detect the weed areas in an image we took from the fields

KEYWORDS:- agronomy, Remote Sensing, hyperspectral, fuzzy logic, neural network, Genetic algorithm, fruit grading, weed detection, patch spraying

1.1 INTRODUCTION:

Precision agriculture was new and developing technology which leads to incorporate the advance techniques to enhance farm output and also enrich the farm

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inputs in profitable and environmentally sensible manner. With these techniques/tools it was now possible to reduce errors, costs to achieve ecological and economically sustainable agriculture.

PROPERTIES OF DIFFERENT AGRICULTURE DATA TYPES

Type of data	*Resolution*	*Accuracy*
Crop yield	***High***	***Low***
topographic	***High***	***Medium / high***
Remote sensing	***Medium***	***Medium***
Soil sampling	***Low***	***High***

2. APPLICATIONS BASED ON IMAGE TECHNIQUES:

In image processing source of radiation was important and the sources were Gamma ray imaging, X-ray imaging, imaging in UV band, imaging in visible band and IR band, imaging in Microwave band and imaging in Radio band.

2.1. Remote Sensing Technique:

In agriculture, Remote Sensing (RS) technique was widely used for various applications. Remote Sensing was the science of identification of earth surface features and estimation of geo-biophysical properties using electromagnetic radiation. RS data and pattern recognition technique was used to estimate direct and independent crop area in the study region. Optical and microwave data used to classify the crop. Chlorophyll and water were represented by optical data, crop geometry and dielectric properties were characterized by microwave. The crop discrimination was carried out using either by visual or digital interpretation techniques. Visual techniques based on FCC (False Color Composite) were generated at different bands and were assigned with blue, green and red colors where as the digital techniques applied to each pixel and use full dynamic range of observations were preferred for crop discrimination. For accurate discrimination a multi-temporal approach was used when single date data fails to do so. Spectral unmixing, direct estimation, crop area estimation, global estimation using confusion matrix and regression estimator were also reviewed. RS used for mapping vegetation which provides information of manmade and natural environments. [4] The focus of review was on remote sensing sensors, image processing algorithms to extract vegetation information along with classification and limitations.
Vegetation extraction using image processing was in two parts:

1. image preprocessing for bad line replacement, radiometric and geometric corrections.
2. image classification such as K-mean for unsupervised and MLC for supervised were reviewed.

Hyperspectral imagery for vegetation mapping was widely used as compared to multispectral as it was capable to discriminate complex mixed pixel community.

2.2 Image fusion :

Image fusion was another technique to improve the vegetation classification as individual sensor may be incomplete, inconsistent and imprecise. They concluded that the Remote sensing was advantageous over traditional methods of vegetation mapping and classification. RS sensed images for extracting endmembers was the difficult problem in vegetation. Vegetation mapping was difficult in case for given vegetation species with relatively homogenous leaf spectral characteristics as it can exhibit marked spectral variance due to variability in background spectra. Endmember extraction algorithm (EEA) was used to extract the information from remotely sensed images. Its enhanced version support vector machine – based endmember extraction (SVM-BEE) provides highly accurate results. Complex image (AVIRIS) which comprise large number of classes in limited area was used to test the efficacy of SVM-BEE and N-FINDR endmember algorithms in linear mixing models. SVMBEE shows better performance as compared to N-FINDR and SMACC. The better performance of SVMBEE was because of the capability of support vector to convex hull was superb as well as robustly noise-tolerant and was able to accurately estimate endmembers.

Commonly used image classification techniques were multi-stage classification, unsupervised clustering, density slicing with thresholds, and decision tree classifications. Normalized Difference Vegetation Index (NDVI) proved to be important for identifying irrigated areas in local scale studies as it was directly used as input to classification algorithm. Green index and Relative sensitivity index were calculated on the basis of reflectance and irrigation. Thermal imaging produces better results but cannot be accepted universally in agriculture applications as the plant physiology and climatic conditions varies from region to region.

3. WEED DETECTION :

The term is occasionally used to broadly describe species outside the plant kingdom that can live in diverse environments and reproduce quickly. Weed detection techniques used algorithms based on edge detection, color detection, classification based on wavelets, fuzzy etc. Real time weed recognition system for identifying outdoor plant using machine vision uses edge based classifier to identify broad and narrow weeds. Images acquired in RGB were converted to gray scales and used to process as binary image. Bright pixels in dark background were identified as weed and classified as in broad and narrow using threshold values. The limitation that proposed model does not classify mixed weeds. In color detection method images were captured adjusting color gains and shutter time to gray plates. Excessive green and thresholding was used for segmenting volunteer and non volunteer potato plant regions. Image was then transformed using EGRBI matrix to separate intensity information. EG and RB values help to separate potato pixels from sugar beet pixels. Pixel classification based on K-means clustering and Bayes classifier was used to measure the Euclidean distance. ART2 classifier was also tested for Euclidean distance based clustering. Objects classified on threshold value were identified as potato plants VP and sugar beet SB. Excess color Ex-C filter was used to remove the color red and blue with green as an intensity value. Ex-C was implemented using formula 2*G-R-B. Gray level co occurrence matrix and FFT were used as feature extraction tools. GLCM represents the occurrence of gray levels in an image and its its relationship in co-occurrence matrix. EX-Color based approach was better than gray scale for better classification of weeds

Wavelet based classification for weeds using Gabor wavelet (GW) and GFD for real time herbicide applications classifies weeds into broadleaf and narrow – grass categories. Color images captured were preprocessed to remove red and blue using modified excess green MExG. This information was applied as input to GW and then followed by Gradient Field Transform.. Spatial locality, orientation selectivity and frequency characteristics made Gabor wavelet popular in image analysis. Convolution between MExG and GW provides the best contrast levels between plants and soil compared with R and B channels. Gradient field transform was applied for feature selection based on histogram or gradient bars and curve fitting on gradient bar which shows improved results over GW approach. ANN was used as classifier to classify weeds into grass and broadleaves. GW and GFD success rate was higher than GW used separately.

Case based reasoning (CBR) was problem solving technique using previous knowledge about problem and solution. Images were categorized into light- sunny or cloudy, presence of sowing errors-true or false, crop growth stage-low, medium, high and infested field. Images were processed through segmentation methods -S1, S2, elimination- E1,E2,E3 and filtering- F1 and F2 were compared with decisive variables, advantages and drawbacks. Characteristic attributes were saved as Case indexing, then case representation and case base structure was followed. Case retrieval, case retention and learning were the steps where new cases were considered. Evaluation has been performed with different combinations of CBR methods proposed and compared. CBR technique shows high correlation coefficient as compared to non-CBR methods, Experts.

Fuzzy algorithm for site specific herbicide application was developed for reducing application of herbicides and protection of environment from pollution. Fuzzy algorithm was applied in triangular and trapezoidal membership functions for input and output: low, normal and high functions for weed coverage thin, average, thick for weed patchiness and small, medium and large for herbicide applications.

Weed Classification is a necessity in identifying weed species for control. There are two types of weed based on the frequency of the edges present in them.

They are:

1. Weed with narrow leaves (have less edge frequency).

Fig 1: weeds with narrow leaves

2. Weed with wide leaves (have more edge frequency).

Fig 2: weed with wide leaves

i) Inter Row Weed Detection:

In this method we can detect the weed that is present in between the rows of the crop. Here it will process the images taken in real time to get the weed areas. We will take pictures at 25 frames per second. Each frame needs to be operated for 0.04 sec. Here we will take the first eight frames generated in 0.3 sec time and we will perform the logical AND operation between them to get a reference image called crop row image. This reference crop row image will be changed after 0.3 sec and will be replaced by the new crop row image formed by the AND operation of the frames obtained in next 0.3 seconds. After obtaining the reference image we will compare the next coming image with it and we will get the weed output. The things which are present in the processed image and are absent in the reference image will be treated as the crop. For this we will do XOR operation of the processed image with the already existing reference image will give the output image containing the weed that is present in between the rows. The main disadvantage of this method is that it cannot identify the weed that is present in between the plants in a crop row. Also if the crop is present outside the row then it will take that as a weed. So we cannot relay much on this method to detect the weed.

ii) Inter Plant Weed Detection

Inter row weed detection does not deal with the weed between the plants in the rows. In order to overcome this problem Inter Plant Weed Detection is employed

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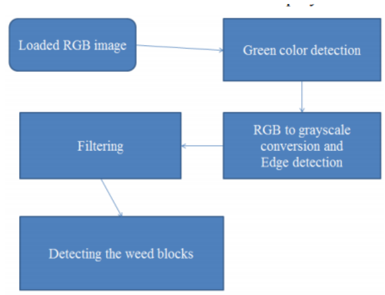


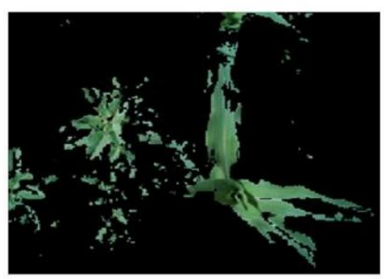
This part of the algorithm prepares an image for further advanced processing and is consists of: Loading the image from source, color segmentation and edge detection.

This is the input image we have taken for weed detection.

4. IMAGE SEGMENTATION:

i) Color segmentation:

It is one of the image segmentation method used to separate the crop (which also include weed) from the background. This is done through Kmeans clustering. The method helps in separating all the visually distinguishable colors from one another. The L*a*b* color space (also known as CIELAB or CIE L*a*b*) enables to quantify these visual differences. The L*a*b* space consists of a luminosity layer 'L*', chromaticity-layer 'a*' indicating where color falls along the red-green axis, and chromaticity-layer 'b*' indicating where the color falls along the blue-yellow axis. All of the color information is in the 'a*' and 'b*' layers. The difference between two colors can be measured using the Euclidean distance metric. Clustering is used to group the pixels of same colors into group of objects, thereby making it easy to segment. The output image comprises of only two colors. The desired image after color segmentation consists of green color (the crop and the weed) and the remaining part of image black, making the image feasible to the step in the process, edge detection.

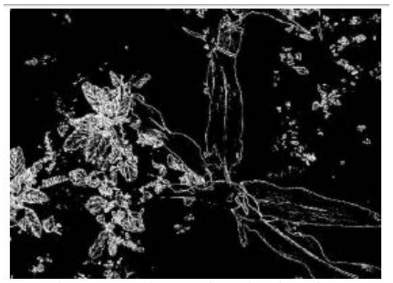


output image after color segmentation

ii) Edge detection:

It is also a method of image segmentation which uses the fact that the edge frequencies and veins of both the crop and the weed have different density properties (strong and weak edges), to separate the crop from the weed.

The image after both color segmentation and edge detection is left with the edges and veins of both the crop and the weed in white and the remaining part completely black.



output image after edge detection

Although several sophisticated and accurate methods for color segmentation exist, many of them are not fast enough for real-time purposes. As in color segmentation, several methods with different accuracy and speed are available which their most well-known ones are Canny and Sobel edge detection algorithms. The operations like color segmentation, edge detection make the image ready for the next operation called **Filtering**. Filter here is used for recognizing regions in which edges appear with a frequency in a specific range (weed frequency range). Here the image after the edge detection in above step as input. To apply filtering the image has to be divided into blocks of certain size. There is a trade-off between the block size and gained accuracy.

~If the block size is too large, frequency estimation can be faulty due to existence of both crop and weed in the same block.

~If it is too small, the frequency cannot be calculated correctly because of inadequate number of edges in a block.

A small block may detect the inner part of the weed leaf as the crop because of less number of edges in it. Also in choosing the threshold value we need to take care because its value depends on two factors. They are:

1. Type of weed present
2. Type of crop.

The above factors affect the threshold value in this way: if we have narrow crop leaves and wide weed leaves then we can say that weed has more edge frequency than the crop, so here the threshold value will be more. Otherwise threshold value will be less. In this paper we take the case of corn crop where the edge frequency of weed is more than that of crop. For knowing the value of the edge frequency here, first we took a image which contains pure weed and calculated the number of edges in it by using for loops and then we have calculated the number of edges per block for pure weed. That turned out to be approximately 900. Then we did the same by taking pure plant image and its edge frequency is approximately 100. So in this paper we took 500 as threshold value so that all weed can be detected. Coming to our case in this project we have taken an image of the size approximately 400 x 500 pixels. And we have divided it into 100 blocks each of size 40x50 pixels. In the program which we wrote, we have used for loops for counting the number of pixels and if loop for keeping the threshold value. If the edge frequency is greater than the threshold value then we detect that block as weed block and again by using for loops we convert all the pixels in that block into white pixels. As a result we will be getting an image which contain weed blocks as total white blocks and other blocks remains unchanged. We will also display the block number by using display function in MATLAB. The resulting image will look like:

Final output after filtering showing the weed affected areas as white blocks.

5. APPLICATIONS IN FRUIT / FOOD GRADING:

Need of accurate grading, sorting of fruits and foods or agriculture products arises because of increased expectations in quality food and safety standards. It causes increased processing and labor work. Computer vision and image processing were non destructive, accurate and reliable methods to achieve target of grading. Image processing in agriculture and food industries has been applied in the areas of sorting, grading of fresh products, detection of defects such as dark spots, cracks and bruises on fresh fruits and seeds, etc.

Image processing concepts for grading of bakery products, fruits, vegetables and grains were considered in. Fruits characterized by color, size and shape, its condition in pre and post harvesting, damages were attributes for grading. Vegetables specially roots, tomatoes, mushrooms were also compared with its attributes for grading purpose. Socio economic Limitations were also discussed. Similar kinds of approaches for grading of Grains, fruits, vegetables were reviewed by other researchers.

The methods or techniques in image processing such as image segmentation, shape analysis and morphology, texture analysis, noise elimination, 3D vision, invariance, pattern recognition and image modality were applied for grading these categories. Automated system of sorting food and agriculture products provides rapid and hygienic inspection with computer vision. For raisin grading specially designed hardware which captures the image was developed. Image was processed with VB based algorithm for color and size of raisins. Pixel colors in RGB form were calculated and with position control, upper and lower pixels were determined. From these pixels middle position can be determined and features were extracted. Raisins with bad grade were identified as background and others in good category. From confusion matrix the classification rate obtained was higher as compared to human experts. This algorithm was also applicable to lentil and almond. For detection of skin defects in citrus fruit PCA method was used for **Multivariate Image Analysis** (MIA). Images captured with 3CCD camera were applied to MIA algorithm which unfolds the images in RGB and spatial information. Reference eigenvector formed by training with defect free citrus was used to compute T2 matrix. Threshold value decides the defect in fruit, if the value was greater, then it was considered as defect. This leads to preparation of defect map. Multi-resolution and post processing techniques were used to speed up the process with three different measures. In study of 9 defects detection average correct detection was 91.5% and classification into four damaged /sound classes was 94.2%.

K-mean clustering for strawberry grading into different categories on the basis of shape, size and color was proposed. The hardware includes camera, photosensors with single chip microcomputer. Captured image was converted to G-R so that background can be separated after threshold. K-mean clustering was used to grade the strawberries. Shape was graded into long-taper, square, taper and rotundity using R-G channel and segmentation. This was used to find out contour helpful in indentifying the major axis of direction. Similarly horizontal line with threshold value was identified for size. Strawberry color feature was extracted by the dominant color method on a* channel in La*b* color space. System was also proposed for multi-feature gradation system. Size detection observed has average error of 3.55, color detection success rate was 88.8% and overall grading has 94%. Fruits and vegetables classification using features and classifiers with fusion was proposed. [27] Images were the collected as a data over the period for distribution in supermarkets. 8bit color images were classified on the basis of statistical, structural and spectral basis. Image descriptors like global color histogram, Unser's descriptors, color coherence vector, border/interior, appearance descriptor, supervised learning techniques were considered. For background subtraction k-mean was utilized.

Image analysis was carried out by separating R, G and B using Bayer filtering. Each plane was separated from blank image to identify the background and object. Three intensity histograms extracted as features were used for classification. Each histogram represents the scaled red, green, or blue pixel. Intensities from the wheat kernel image were computed. Parameters like mean and standard deviation of the red, green, and blue intensities were also computed. Linear Discriminant analysis was used as classifier. Classification accuracy was 97% compared to histogram feature method (88%). Average Accuracy of classification was greater than the commercial color sorters.

The hardware based grain classifier was developed with three CMOS sensor and FPGA combination for higher speed of inspection. Red pixels were used to classify the red and white wheat grains. Parameter like variance was also utilized. The same hardware was used for popcorn classification of blue-eye damage. Classification accuracy rate was 91 % in wheat and corn cases. The classification of vitreous and non-vitreous durum wheat kernels using imaging systems based on real time soft X-rays or transmitted light was proposed. X-ray images were analyzed using histogram technique.

To avoid illumination and manmade disturbances images were captured with flat bed scanner. Features were extracted using morphological feature analysis and color feature. Morphological feature analysis of corn kernels was used to extract basic geometric features such as area, perimeter and derived shape features. Color analysis was used for classification. Mean and standard deviation of these color components were calculated to extract 28 color features for identification. To reduce computational burden and to enhance the performance of classification stepwise Discriminant analysis was used.

6.CONCLUSION:

Image processing technique has been proved as effective machine vision system for agriculture domain. Imaging techniques with different spectrum such as Infrared, hyper spectral imaging, X-ray were useful in determining the vegetation indices, canopy measurement, irrigated land mapping etc with greater accuracies. Weed classification which affects the yield can be correctly classified with the image processing algorithms. The accuracy of classification varies from 85%- 96% depending on the algorithms and limitations of image acquisition. Thus with such great accurate classification farmers can apply herbicides in correct form. This approach helps to save the environment as well as the cost. In case of fruit grading systems the segmentation and classification can also be achieved with great accuracy as the case with weed detection. In this case also the classification accuracy can be obtained up to 96% with correct imaging techniques and algorithms. Then we gave the input of the weed blocks to the automatic sprayer which sprays only in these blocks. By doing so we can reduce the usage of weedicides, thus saving the environment. If we have two are more types of weeds of different edge frequencies present in the same field. Then the threshold value must be less than the minimum edge frequency of the weeds present. If a small weed is present separately in the field means not in a group then it cannot be detected because it cannot meet the threshold condition. If both the weed and crop have nearly same edge frequency we should be very careful in selecting the threshold value. The weed block numbers from the filtering step cannot be given automatically to the motor, it has to be done manually. This will take some time. Thus we can conclude that image processing was the non invasive and effective tool that can be applied for the agriculture domain with great accuracy for analysis of agronomic parameters.

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