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A Survey on Weed and Pest Detection System

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Abstract: ***Weed control is essential and critical operation and can affect crop yield. Fertilizers play an important role in weed control but their role is under criticism due to perceived excessive use and potentially harmful to the environment. This paper intends to focus on the survey of weed and pest detection using image processing in agriculture field. Several studies say that selective patch spraying considerably reduces herbicide use. Selective Patch spraying uses remote sensing and is not suitable for most farms. The machine vision based approach uses size, shape, texture, color and location based features to discriminate between weed crop and disease affected leaf or plant.***

Keywords: weed detection; pest detection; image processing; neural network, feature extraction.

I. INTRODUCTION

This paper focuses on the survey of weed and pest (diseases) detection using image processing in agriculture Field. In agriculture, Farmers have a wide range of diversity to select suitable vegetable crops. However, the cultivation of these crops with the best quality produce is highly technical. When crops and weeds are grown, identification of the weeds by using leaf parameters such as size, shape, color and texture are used. There are lots of content based retrieval systems which are applied to general image Databases (CBIR) and few plant databases. This has led to the thought of identifying the different diseases of leaves of plant and weed available around us.

II. METHODS

Methods for weed and pest detection system are,

- Image Acquisition
- Pre-processing
- Feature Extraction
- Classification

A. Image Acquisition

Using a digital camera image of weed is captured in RGB format. The captured image is converted into a gray scale image to minimize the array of image. In image processing, it is easier to process in two dimensional grey images rather than RGB three dimensional arrays.

B. Pre-Processing

Captured leaf images are not suitable for feature extraction and classification, because captured images are affected by various factors such as noise, lighting variations, climatic conditions, poor resolutions of an image, wanted background etc [2]. Following are some of pre-processing tools.

1) RGB Images to Gray Scale Images: Converting RGB color image is converted into gray scale image. Vegetation method introduced by Woebbecke et al [11].

$$ExG=2\times G-R-B+127 \quad (1)$$

2) Gray Scale Images to Binary Image: Gray scale images are converted into binary image by using thresholding method described in the research [10].

3) Filtering Techniques: Filtering techniques is used to remove the noise**.** The ordinary filters such as low pass, high pass, Sobel etc. are used to enhance the raw image as well as to remove unwanted signal in the original image (Gonzales, 1992). [4]

Low pass and high pass filters have been used to analyze the weed images. Filter technique is used to remove noise as well as to detect the edges of an object. Smooth and sharp transitions in an image contribute to low and high frequency content in the image. Two Dimensional ideal Low pass filters

$$H(u,v)=\begin{cases}1\ if\ D\ (u,v)\le\ Do\\ 0\ if\ D\ (u,v)\ >\ Do\end{cases} \quad (2)$$

Where Do - specified nonnegative quantity

D (u, v) is the distance from point (u, v) to the origin of the frequency plane.

Two Dimensional ideal high pass filters [4]

$$H(u,v)=\begin{cases}0\ if\ D\ (u,v)\le Do\\ 1\ if\ D\ (u,v)>\ Do\end{cases} \quad (3)$$

WhereDo is the cutoff distance measured from the origin of the frequency plane?

D (u, v) is the distance from point (u, v) to the origin of the frequency plane.

4) Wavelets: Statistical modeling is much easier if some pre-processing is carried out on the input Images. Typical pre-processing is done via transformation of image pixel values into suitable space where simple methods with a small number of parameters can describe the data. The wavelet transform is one such efficient tool to represent images. [1]

The wavelet transform allows multiple resolution analysis of an image thereby extracting relevant information from an image. The various kinds of wavelet transform which can be performed on an image are continuous Wavelet transform (CWT) and discrete wavelet transforms (DWT) and many more methods.

Discrete wavelet transforms (DWT)

In numerical and functional analysis, a DWT is wavelet transform for which transforms wavelets into discretely sampled. The haar DWT illustrates the desirable properties of wavelets in general. First it can be performed O(n) operations; second it captures not only a notation of the frequency content of the input, by examining at different scales but also temporal content [1]. The haar transform can be expressed in the matrix form.

Gabor Wavelet (GW)

GW has been used efficiently in various computer vision applications. This method is needed for selecting filter parameters to maximize the discriminating power of filters. In computation two variables are used. They are Frequency and orientation. Gws

is widely used in image analysis because of spatial locality, orientation selectivity and frequency characteristics and are popular in pattern recognition and image processing application [7].

5) Eroding and dilation image object: Erosion and dilation are morphological operations. Eroding decreases the brightness of object background. The binary images are dilated to remove holes and blobs in the object [11].

C. Feature Extraction

After pre-processing features are extracted for discriminating weed and crop. Selection algorithms weight features according to their discrimination abilities and select the ones that allow the best discrimination of classes. PCA weighting is one example, which uses the co-efficient of a principal component analysis to weight the features [3].

1) Color Features: Color and shape analysis techniques for discriminating crop, weeds and soil. In real time applying of herbicides uniformly across a whole field, seems undesirable in both economic and environmental terms. Color-based methods are more robust to partial occlusion and generally require less computation than shape-based methods (Slaughter D. , Giles, Fennimore, & Smith, 2008). Color-based methods have shown promise in fruit identification but less so with plant classification. For example, color-based methods can be used to identify Fuji apples with 88 percent accuracy (Bulanon, Kataoka, Ota, & Hiroma, 2002) and eggplants with 67 percent accuracy (Hayashi, Ganno, Ishii, & Tanaka, 2002) [3] when combined with shape-based methods. Burks et al. (2000) noted that color could accurately segment the plant from the background, but was inadequate for plant classification because leaf orientation with respect to the light source significantly affected the classification accuracy.

The weeds are extracted from the images using image processing and described by shape features [4]. A classification based on the features reveals the type and number of weeds per image. Features are used, which enable an optimal distinction of the weed classes. The selection can be done using data mining algorithms, which rate the discriminants of the features of prototypes. Color features are extracted from color information of leaf by using statistical methods

- Mean
- Standard deviation
- Skewness
- Kurtosis

2) Shape Features

Shape-based imaging techniques are able to classify plants with almost 90 percent accuracy in laboratory environments (Woebbecke, Meyer, Von Bargen, & Mortensen, 1995) as well as field tests (Lamm, Slaughter, & Giles, 2002) under ideal conditions**.** The first step describes unconnected objects as a function of some geometrical features [11]:

- Major axis length
- Aspect ratio
- Area
- The ratios of the major (minor) axis
- Length squared to the area
- Roundness
- Circularity
- Compactness
- Intercepts

Thus, each object was represented as a vector in the feature space. In order to determine which features were the most useful to discriminate between weeds and crop, a primary selection process was carried out.

3) Texture features

The co-occurrence matrix is used to obtain textual features. The co-occurrence matrix method of texture description based on the repeated occurrence of gray level configuration is described by a matrix of relative frequencies [4].

Some of the textural features are given below [11]

- Energy
- Entropy
- Contrast
- Inverse Difference moment
- Correlation

Detection systems use shape, texture, or color parameters to classify various types of plants (Slaughter D. , Giles, Fennimore, & Smith, 2008) and frequently employ machine intelligence with learning capabilities in order to deal with the dynamic complexity of unstructured environments (von Wichert, 1998). The selection of the image processing techniques and the classifier algorithm are both important in detection systems. The image processing techniques process the raw image to find features, such as shape outlines and color.

Gradient Bar

An efficient approach for selecting the most discriminating and informative features is gradient bar. Feature selection is commonly used in machine learning. To classify grasses and broad leaf weeds accurately, need to select and extract unique feature vectors. [6]

Principal component analysis

After feature extraction is performed feature vectors are need to be minimized. PCA is a spatially technique which has been widely used in a number of fields to reduce the dimensionally of the dataset. [5] The main goal of PCA is to find a new set of dimensions that best suite the variability of data and explains the difference in the observations and can be used in simplifying the analysis and visualization of high dimensional dataset.

The steps involved in PCA can be summarized as Obtain the input matrix; calculate and subtract the mean; calculate the covariance matrix; the Eigenvectors; Eigen values and then forming a new feature vector; once the new feature vector is formed; the new dataset with low dimensions is derived. [1] The new feature vectors are passed to classifier.

D. Classification

Following are some of classification algorithm used to classify weed and crop. Feature vectors are passed as input to the classifiers.

1) Neural Networks: Neural Network is very popular in pattern recognition and classification. The efficiency of neural network in weed and crop discrimination using image processing is proven. [12]

2) Artificial neural network: Multi layered back propagation neural network (BPNN) as a classifier of different produce and in automatic detection of disease. The classifier is trained, validated and tested using images of different agricultural products. [2]

Grape leaf disease is detected in [15] from color imagery using hybrid intelligent system. They used self organizing maps &back propagation neural networks to recognize colours of grape leaf. This information is used to segment grape leaf pixels within the image. Then the grape leaf disease segmentation is performed using modified self organizing feature maps with genetic algorithms for optimization &support vector machines for classification. The segmented image is filtered using Gabor

wavelet which allows the system to analyze leaf disease color features more efficiently. The support vector machines are then applied to classify types of grape leaf disease.

3) Probabilistic Neural Network: PNN is used for leaf identification. Training of PNN is fast and optimum classification is achieved. Existing Weights are not altered but new neurons are added. This is well suited for real time weed detection applications. [13]

4) Genetic Algorithm: A genetic algorithm for weed extraction use combinational methods such as segmentation of vegetation and soil, crop row elimination and weed extraction [9].For segmentation- S1 and S2 methods, for crop row elimination- E1, E2 and E3 methods and for weed extraction- F1 and F2 methods were proposed. S1 method combines RGB to gray conversion and Gray to BW using threshold values, where as S2 directly converts RGB to BW depending on pixel property. E1and E2 algorithms in which crop elimination was done by taking column pixels into considerations. F1 and F2 for weed extraction use the filtering and region extraction. Then the combinations of S, E and F were processed to find out the optimum value by genetic algorithm method. The results of the methods were compared with biomass and showed accuracy up to 96% with small computational complexity.

5) Fuzzy Algorithm: A fuzzy algorithm for site specific herbicide application was developed for reducing application of herbicides and protection of the environment from pollution. [10] Greenness ratio calculated to identify the pixel as a part of the image which indicates the weed coverage area in an image. Different illumination conditions and shadow makes it difficult to decide the threshold for greenness. Weed patchiness was calculated over the neighbourhood and map was developed.

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 coverage mapping was carried out between 1% to 5% and above which then related to herbicide applications. Application of image processing and fuzzy logic determines the weed coverage and useful for site specific herbicide application. Fuzzy logic is used to determine/ recognize presence of weed and how much herbicide is used to apply in the farm. Fuzzy logic automatically manages the fertilizer application.[14]

6) Edge based classifier: Edge based weed classifier is developed to classify images into broad and narrow class for real-time selective herbicide application. The algorithm has been tested on farms at various locations, which is very effective in weed identification. Further the results show a very consistent performance on weeds under varying field conditions. The resulting analysis shows over 94 % classification accuracy over 140 sample images (broad and narrow) with 70 samples [8].

7) Clustering: A supervised classifier that uses the training data of the prototypes is used to assign classes to objects. Unsupervised classification algorithms also known as clustering can be used if no training data exists; [3] These kind of classifiers was used before class information was available and before the manual selection of prototype has taken place; these algorithms aggregate similar objects to cluster according to further information.

III. CONCLUSION

The image processing technique proved as an effective machine vision system for agriculture domain. 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 accurate classification planter can apply herbicides in correct form. This approach helps to preserve the environment as well as the cost.

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