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Machine Vision Guided System for Classification and Detection of Plant Diseases using Support Vector Machine

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***Abstract* – Plant diseases have turned into a dilemma as it can cause significant reduction in both quality and quantity of agricultural products. We propose and experimentally evaluate a software solution for automatic detection and classification of plant leaf diseases (Classifier- Support Vector Machines) using a machine vision guided system. Studies show that relying on pure naked-eye observation of experts to detect such diseases can be prohibitively expensive, especially in developing countries. Providing fast, automatic, cheap and accurate image processing based solutions for that task can be of great realistic significance. The proposed system is a combination of robotics and image processing - a step towards automation. The robotic system is used for real time crop monitoring and image acquisition, it is a complete wireless system controlled by the laptop using Bluetooth device and a T.V. tuner for video processing. The acquired image will be transferred to the host laptop. The developed processing scheme consists of using color transform followed by the segmentation phase. In the first step we identify the mostly green colored pixels. Next, these pixels are masked based on specific threshold values. The other additional step is that the pixels with zeros red, green and blue values and the pixels on the boundaries of the infected cluster (object) are completely removed. Using color segmentation the diseased part is segmented and an algorithm is developed for feature extraction. Acquired features are used as criteria for identification of the disease. Further we train samples and test them using SVM classifier and identify the diseases. Additional feature is the GUI with a voice output in Marathi which includes the name of the identified disease and its probable solution according to the database. For experimental purpose we use Mango plant. The technique is a robust technique for the detection of plant diseases.**

***Keywords* – SVM, Plant Leaf Diseases, YCbCr, Color Segmentation, Gabor Filter.**

I. INTRODUCTION

Plant diseases cause losses in abundance to both the quality and quantity of agricultural products. Economic losses and a threat to food security are complimentary packages.

As plant diseases cause huge losses to the crop yield, its adverse effects are seen on agricultural products like fruit products, medicines. At biological level, the requirements are for the speedy and accurate identification of the causal organism or environmental condition, accurate estimation of the severity of the disease and its effect on yield.

Image processing has been proved to be effective tool for analysis in various fields and applications like the agriculture sector where the parameters like canopy, yield, quality of product were the important measures from the farmer's point of view. Many times expert advice may not be affordable, majority times the availability of expert and their services may consume time. Image processing along with availability of communication network can change the situation of getting the expert advice well within time and at affordable cost since image processing is an effective tool for analysis of parameters. We intend to focus on the survey of application of image processing in agriculture field. Few examples of applications of image processing in agriculture are imaging techniques, weed detection and fruit grading. 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. [6]. This new tool helps to improve the images from microscopic to telescopic range and also offers a scope for their analysis. It, therefore, has many applications in biology.

Therefore, a Machine vision guided system would probably be exceedingly beneficial by bringing all automation and image processing together. Appropriate computer based information and/or decision support systems can aid in achieving analysis and solution options at a reduced cost. Efficient and accurate implementation of automated system needs a comparative study of various techniques available. This project aims to analyze real time data of plants using a machine vision guided system and process the acquired image, detect the disease and provide solutions for the same.

For experimental purpose we have chosen Mango plant. Mango is the king of fruits. Cultivation of mangoes started in India about 500yrs ago. There are hundreds of Mango varieties in India from *Chusa* to *Langra*. Close to half of the world's mangoes are produced in India making India, the topmost producer of this fruit. Some of the Mango trees can bear fruits even after 300yrs. Thus we have worked on Mango plants and its diseases.

II. Literature Survey

Agriculture in Maharashtra is a predominantly rainfed (83%). Cotton and soybean are the two major kharif crops of Maharashtra that covers 62 lakh hectares and collectively occupies 45% of the total area under kharif crops. During 2008-09, there was severe outbreak of Spodoptera litura coupled with Helicoverpa armigera and other leaf eating caterpillar pest on soybean crop in Marathwada and Vidarbha regions of Maharashtra State. Crop over an area of 14.64 lakh hectares (48% of area under soybean) was infested out of that 10.44 lakh hectares was having more than 50% infestation level. As such, the crop was almost devastated. Monetary losses due to pest outbreaks were estimated to the tune of Rs.1392 crores [7].

A few reasons which come to notice when we give a thought over this severity are:

- Lack of knowledge to understand pest appearance.
- Negligence of different agencies involved in agricultural enterprises of the region.
- Indiscriminate use of pesticides and their resources.
- Poor transfer of production technology to farmers.
- Poverty.
- Poorly resourced R & D.
- Improper identification and quantification of plant diseases.

The current conventional methods adopted for detection and identification of plant diseases are contacting experts. The naked eye observation of experts is the main approach adopted in practice for detection and identification of plant diseases. But, this requires continuous monitoring of experts which might be prohibitively expensive in large farms [1]. Further, in some developing countries, farmers may have to go long distances to contact experts, this makes consulting experts too expensive and time consuming and moreover farmers are unaware of non-native diseases. Automatic detection of plant diseases in an important research topic as it may prove benefits in monitoring large fields of crops, and thus automatically detect the diseases from the symptoms that appear on the plant leaves [3]. This enables machine vision that is to provide image based automatic inspection, process control and robot guidance. Comparatively, visual identification is labour intensive, less accurate.

Government of Maharashtra has implemented a project - CROPSAP (Crop Pest Surveillance and Advisory Project) in 2011-12.

Programme consists of three parts i.e.

A. Pest monitoring-cum-surveillance based advisory system.

B. Awareness creation

C. Supply of chemical and biological pesticides in critical situations on 50% subsidy as a plant protection measures.

A. Pest monitoring-cum-surveillance based advisory system

Random survey of Soybean, Cotton and Tur in kharif and gram in Rabi is to be conducted in 78 Subdivisions of 29 districts in Maharashtra. One pest scout will survey 12000 hectors of area of Cotton and Soybean and for this purpose 550 pest scouts have been deployed. For monitoring ten pest scouts one Agril. Supervisor has been deputed. In all 64 Agril Supervisors have been deployed for the monitoring work. To upload the data and to send SMS advisories to farmers services of 64 data entry operators (one for each Agril. Supervisor) have been made available. Advisories will be issued on every Monday and Thursday in a week through various publicity media. Last year 29.53 Lakh advisory SMS have been sent to the farmers.

B. Awareness creation among the farmer regarding pest and diseases

To create required awareness about the pests and their management practices field extension staff is being trained at SAU level. With the help of this field staff farmers will be trained in weekly village level meetings. In these meetings pest situation and management strategy will be discussed.

C. Supply of chemical and biological pesticides in critical situations on 50% subsidy as a plant protection measures

To handle the critical situation and to combat pest attack critical inputs will be made available to farmers on 50 % subsidy base. Divisional Joint Director will supply and monitor timely supply of critical inputs [7].

The current electronic devices for capturing images have been developed to a point where there is little or no difference between the target and its digital counterpart. Once the image of a target is captured digitally, a myriad of image processing algorithms can be used to extract features from it. The use of each of these features will depend on the particular patterns to be highlighted in the image. The automatic classification by computer vision of plants has received increasing attention in the recent past For instance; some relevant machine vision algorithms can classify plants into either crop or weeds

Nowadays, Machine-vision has become one of the important applicable techniques in micro-precision agriculture. For the real-time crop monitoring in greenhouses, machine vision can identify emerging stresses and guide sampling for identification of the related stressor.

III. System Architecture

System architecture of proposed method comprises of combination of robotics (hardware) and image processing. The robotic system will be used for real time crop monitoring and will be used for image acquisition.

IV. Methodology

A. Hardware Description

We are using a robotic system for real time crop monitoring and image acquisition, the digital images are acquired from the farms using wireless camera present on the robotic system. The movement of the robot will be controlled via laptop using Bluetooth. We send control signals via hyperterminal. The directions for movement are decided on the bases of the live video transmission of the surroundings of the robot which is done using a T. V. tuner. Further image-processing techniques are applied to the acquired images to extract useful features that are necessary for further analysis.

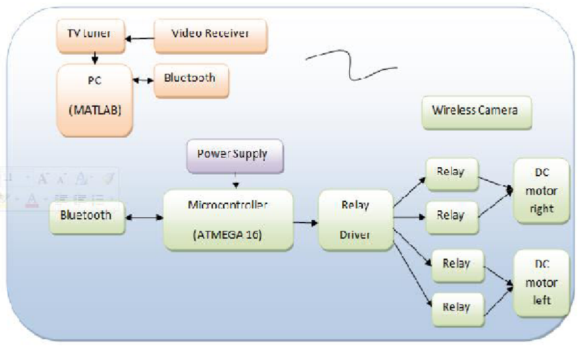

Fig.1. Hardware Block diagram

B. Software description

The step by step procedure of proposed system:

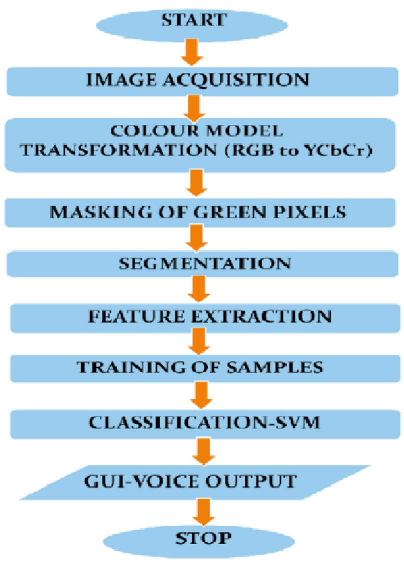

Fig.2.Flowchart of Software

a. Color transformation structure

In this step we are first color balancing the input color image by taking the R, G, B components of the input image. It is the global adjustment of color intensities of R, G, B. Further we are taking Inverse of the Average values of the R, G, and B. Then we calculate the scaling factors and using these scaling factors scale the R, G, B matrix. Now we obtain a well balanced illuminated image.

Firstly, the RGB images of leaves are converted into YCbCr color space representation. YCbCr is chosen as it is widely used in digital video image processing. Also YCbCr is linear color model thus there is less transmission of noise. In this format, Luminance information is represented by single component, Y and color information is stored as two color difference components, Cb and Cr. By keeping Cb and Cr constant, Y can be changed thus maintaining the original chromaticity. Cb threshold is kept between 76 and 127 while Cr threshold is kept between 132 and 173.

b. Masking green pixels

First, we identify the mostly green colored pixels. After that, based on specified threshold value that is computed for these pixels, the mostly green pixels are masked as follows: if the green component of the pixel intensity is less than the pre-computed threshold value, the red, green and blue components of the pixel is assigned to a value of zero. This is done in sense that the green colored pixels mostly represent the healthy areas of the leaf and they do not add any valuable weight to disease identification. Thus, this significantly reduces the processing time.[3]

We are obtaining Disease segmentation by Assigning value one to diseased part of the leaf and zero value to the non-diseased part.

c. Segmentation

Segmentation is a process that partitions an image into regions. We are using color segmentation. To segment objects of a specified color range in an RGB image we obtain an estimate of the average or mean color that we wish to segment. Firstly colors in the image are coarsely quantized without significantly degrading the colour quality. Thus the choice of YCbCr colour model transformation is appropriate in this case. The purpose is to extract a few representing colors that can be used to differentiate neighbouring regions of the image. The objective is to classify each RGB pixel in an image as having a color in the specified range or not. The colours between two neighbouring regions are distinguishable is the basic assumption for colour segmentation.

Below figures show output for color segmentation:

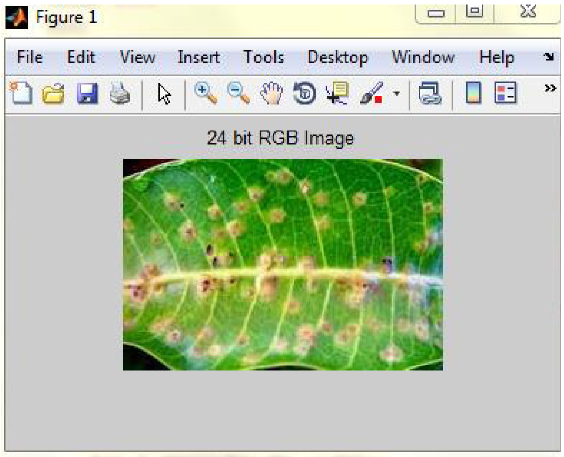

Fig.3. 24 bit RGB image

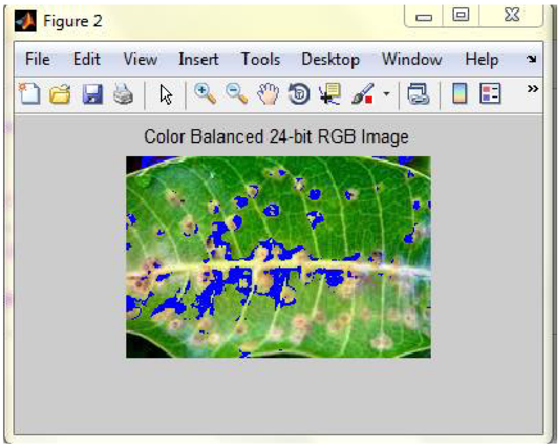

Fig.4. Color balanced 24 bit RGB image

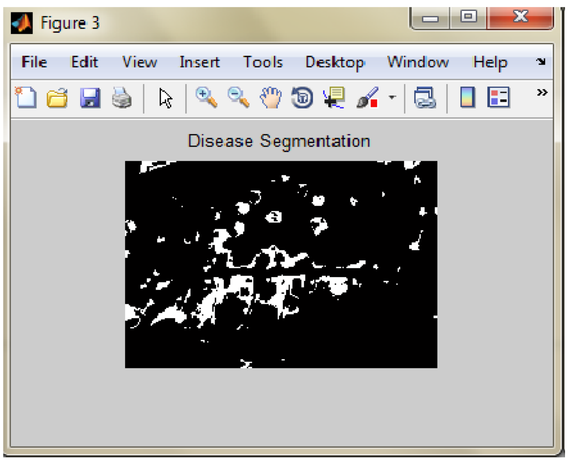

Fig.5. Color segmented binarized output

d. Feature extraction

In the proposed approach, the method adopted for extracting the feature set is the *Wavelet Transformation*. The simplest form of the wavelet transform is the *Gabor Filter*. It is a method, we take into consider the frequency and the orientation to arrive at unique features which represent that image.

Gabor wavelet transform

The image analysis technique used for this study was the well-know Gabor wavelet transform. Wavelet transform could extract both the time (spatial) and frequency information from a given signal, and the tunable kernel size allows it to perform multi-resolution analysis. For example, smaller kernel size has higher resolution in time domain but lower resolution in frequency domain, and is used for higher frequency analysis; while bigger kernel size has higher resolution in frequency domain but lower resolution in time domain, and is used for lower frequency analysis. This great property makes wavelet transform suitable for applications such as image compression, edge detection, filter design, and some kinds of image object recognition, etc. [10]

Named after scientist *Dennis Gabor*, it is a short time *Fourier Transform* used to determine sinusoidal frequency and phase content of local section of signal as it changes over time. The function to be transformed is first multiplied by *Gaussian* function which can be regarded as *window function* and resulting function is then transformed to derive time frequency analysis

$$g(x,y) = s(x,y) * Wr(x,y) \qquad (1)$$

In Eq. 1, g (x,y) is the Gabor Function, s (x,y) is the Gaussian Function and Wr (x,y) is the Window Function.

Gabor transform equation of a signal x (t) is given by:

$$G_x(t,f) = \int_{-\infty}^{\infty} e^{-\pi(\tau-t)^2} e^{-j2\pi f \tau} x(\tau)\, d\tau \qquad (2)$$

The Gaussian function has infinite range and it is impractical for implementation. However, a level of significance can be chosen (for instance 0.00001) for the distribution of the Gaussian function.

$$e^{-\pi a^2} \geq 0.00001; \ |a| \leq 1.9143 \qquad (3)$$

$$e^{-\pi a^2} < 0.00001; \ |a| > 1.9143 \qquad (4)$$

Outside these limits of integration |a| > 1.9143, the Gaussian function is small enough to be ignored. Thus the Gabor transform can be satisfactorily approximated as

$$G_x(t,f) = \int_{-1.9143+t}^{1.9143+t} e^{-\pi(\tau-t)^2} e^{-j2\pi f \tau} x(\tau)\, d\tau$$

This simplification makes the Gabor transform practical and realizable.

Among kinds of wavelet transforms, the Gabor wavelet transform has some impressive mathematical and biological properties and has been used frequently on researches of image processing.

The Gabor Filter

It is a linear filter used for edge detection. Frequency and orientation representation of *Gabor Filter* are similar to those of human neural visual system and it is also an appropriate model for texture representation. In Spatial Domain, 2- Dimensional filter is a Gaussian kernel function modulated by a sinusoidal wave multiplied by a Gaussian function. Because of multiplication (convolution property) the Fourier Transform of Gabor filters impulse response is the convolution of Fourier Transform of harmonic function and the FT of Gaussian function. The Filter has real and imaginary components representing orthogonal direction. The 2 components may be formed into a complex number or used individually [11].

We are taking 16 directions (for accuracy and time efficiency.) Number of bands = 4. Therefore there are total [16*4 =] 64 features (sub filtered images).

The *Gabor Filter* we have used includes the use of *Empirical Equation.*

e. Training of samples

An important assumption made in image classification is that the training data represent the classes of interest. In any supervised classification, the aim of the training stage is to derive a representative sample of the spectral signatures of each class. The quality of training data can significantly influence the performance of an algorithm and, thus, the classification accuracy. The accuracy of the decision rules in the next stage may depend on the accuracy of the standard deviation measure derived from training site statistics. Thus we train data set consisting of feature vector (features: Frequency and orientation). The feature space is compressed using PCA (Principal Component Analysis) and thus the Eigen values give the required feature vector.

f. Classification

Classification is the process of sorting pixels into a finite number of individual classes, or categories, of data based on their data file values. If a pixel satisfies a certain set of criteria, then the pixel is assigned to the class that corresponds to those criteria. Supervised classification (SVM) is more closely controlled by you than unsupervised classification. In this process, we select pixels that represent patterns we recognize or can identify with help from other sources. Knowledge of the data, the classes desired, and the algorithm to be used is required before we begin selecting training samples. By identifying patterns in the imagery we can "train" the computer system to identify pixels with similar characteristics. By setting priorities to these classes, you supervise the classification of pixels as they are assigned to a class value. If the classification is accurate, then each resulting class corresponds to a pattern that you originally identified. SVM works best when the hyper plane formed is flat. It classifies the feature vector according to the patterns trained, first into whether a disease is detected or not any further classified into the types of diseases and thus identification is done.

V. Results

For experimental purpose we have chosen Mango plant. We collected database of 6 diseases (Bacterial Canker, Bacterial leaf spot, Gall Flies, Powdery Mildew, Red Rust, Anthracnose.)

Table 1: Result table

Sr. No	Name of the disease	No. of samples trained	No. of samples tested	No. of samples detected	% Accuracy
1.	Bacterial Canker	3	5	4	80
2.	Bacterial Leaf spot	7	10	9	90
3.	Gall Flies	5	8	7	87.5
4.	Powdery Mildew	8	8	8	100
5.	Red Rust	6	7	5	71.42
6.	Anthracnose	10	15	13	86.6

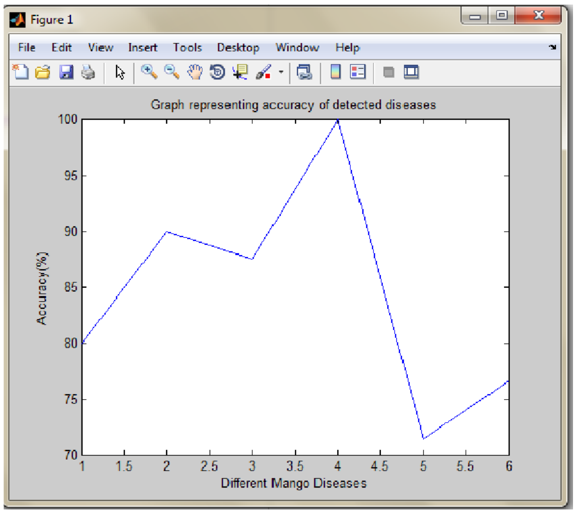

Fig.6. Graph representing Accuracy

We successfully tested the developed algorithm on the acquired images. We can get better accuracy with more no. of samples.

VI. Conclusion

- The previously used techniques like clustering were better for dynamically changing data. Thus it does not know the labels and have to find a structure on its own. SVM makes it easier to find a decision rule with high generalization ability.
- Developed algorithm is time efficient and performs with better accuracy over the existing algorithms. YCbCr color transformation structure gives advantage of a linear color model thus introducing less noise. Luminance information is represented by single component - Y, and color information is stored as two color difference components, Cb and Cr. By keeping CbCr constant, Y can be changed thus maintaining the original chromaticity.
- Development of the grading system involving hardware has automated the system to a greater extent.
- The provided solution is handy and user friendly.

Future Work

- Development of an algorithm to calculate the nutritional deficiency of the crop for healthy agriculture and to save monetary loss.
- Development of a web application for the system for wide range communication and compaction of hardware. (as it could be used on android platform)

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