CHAPTER 1

INTRODUCTION

India is developing country. During this development, contribution of agricultural field is major. It is the primary occupation in India. It has become much more than a means to feed ever growing population. It is very important, where in more than 70% population depends on agriculture in India. That means it feeds great number of people. Farmers are called “the back bones of India”. The agricultural land mass is more than just being a feeding sourcing in today’s world. Indian economy is highly dependent of agricultural productivity. Therefore, in field of agriculture, detection of disease in plants plays an important role. The crop production losses its quality due to much type of diseases and sometimes they occur but are even not visible with naked eye. Farmers estimate the disease by their experience but this is not a proper way. To detect a plant disease in very initial stage, use of automatic disease detection technique is beneficial. Plants become an important source of energy. The existing method for plant disease detection is simply naked eye observation by experts through which identification and detection of plant diseases is done. At the same time, in some countries, farmers do not have proper facilities or even idea that they can contact to experts. Due to which consulting experts even cost high as well as time consuming too. In such conditions, the suggested technique proves to be beneficial in monitoring large fields of crops. Automatic detection of the diseases by just seeing the symptoms on the plant leaves makes it easier as well as cheaper. Plant disease detection is important for agricultural applications to increase the cultivation yield. In plants, some general diseases seen are brown and yellow spots, early and late scorch, and others are fungal, viral and bacterial diseases. Image processing is used for measuring affected area of disease and to determine the difference in the color of the affected area.

With the help of WMSN and image processing techniques it is possible to increase the cultivation yield by building a decision support system which can detect and classify the disease. Wireless Multimedia sensor networks (WMSNs) consists of camera capable sensor nodes and regular sensor nodes deployed in the field of interest to gather information and communicate through wireless links. The main aim of image processing is to alter the visual impact such that the information content improves and as a result the said image is more suitable than original image. This technique helps in getting better visibility of any portion or feature of interest of an image and supplying the information in other portion or feature of an image. The camera nodes placed in the farm captures the image of the plants and processes it to detect and segment the disease. Image segmentation is the process of separating or grouping an image into different parts. These parts normally correspond to something that humans can easily separate and view as individual objects. Computers have no means of intelligently recognizing objects, and so many different methods have been developed in order to segment images. The segmentation process is based on various features found in the image. This might be color information, boundaries or segment of an image. The features extracted from the segmented area are transmitted through the sensor network to the monitoring site. The expert at the monitoring site will classify the disease based on the features received and will provide solutions to the farmers. Precise knowledge of areas where disease has spread would help the farmer to apply appropriate amounts of pesticides to the affected areas, thereby yielding both economic and environmental benefits. Since the sensor nodes have limited memory, energy, and bandwidth it is necessary to develop a less complex disease detection system (DDS) for resource constrained nodes. The image is captured using the camera nodes and the features are extracted for transmission. For extracting the features, the image must be segmented efficiently. Features are extracted based on color, texture, area and cluster. Feature extraction plays a major role for classification. These features are transmitted through the sensor nodes to the gateway which is further transmitted to the monitoring site through internet. The automation system available at the monitoring site makes use of the classifiers and neural networks to classify the disease after which the farmers are alerted. Artificial neural networks and support vector machines (SVM) are commonly used for classification process. An artificial neural network is made up of many artificial neurons which are correlated together in accordance with explicit network architecture. A support vector machine classifier is a discrimination classifier formally defined by a separating hyperplane in machine learning.

In this report, a novel disease detection system (DDS) detects the diseases in leaves and extract the features. The main contribution of the report is a simple and efficient thresholding strategy which makes the segmented image effective for feature extraction. The extracted features are transmitted and at the receiver side the SVM classifier is used to classify the disease. The performance of the system approach is evaluated in terms of accuracy. The features are transmitted in real time using Telos B node and the performance is compared with the raw image transmission. The types of leaves that get captured by a camera node in a field can be of various kinds. The camera captures the image of a particular leaf only when it detects the color change that has appeared on it.

Figure 1: Captured image for testing to detect the disease.

Figure 2: Captured image for testing to detect the disease.

Figure 3: Captured image for testing to detect the disease.

CHAPTER 2

LITRATURE REVIEW

“Diagnosis of pomegranate plant diseases using neural network,” was proposed. In this work the author has proposed a methodology which made use of image processing and neural networks to detect and classify the diseases in pomegranate plant. The diseases considered for demonstration are Fruit Spot, Bacterial Blight, and Leaf Spot. The proposed approach gave satisfactory results with 90% accuracy [1].

“An application of K-means clustering and artificial intelligence in pattern recognition for crop diseases” was proposed. In this study the author presented the technique to classify and identify the different disease through which plants are affected. In Indian Economy a Machine learning based recognition system will prove to be very useful as it saves efforts, money and time too. The approach given in this paper for feature set extraction is the color co-occurrence method. For automatic detection of diseases in leaves, neural networks are used. The approach proposed can significantly support an accurate detection of leaf, and seems to be important approach, in case of steam, and root diseases, putting fewer efforts in the computation [2].

“Detection of unhealthy region of plant leaves and classification of plant leaf diseases using texture features” was proposed. Disease identification process in this study include some steps out of which four main steps are as follows: first, for the input RGB image, a color transformation structure is taken, and then using a specific threshold value, the green pixels are masked and removed, which is further followed by segmentation process, and for getting useful segments the texture statistics are computed. At last, classifier is used for the features that are extracted to classify the disease. The robustness of the proposed algorithm is proved by using experimental results of about 500 plant leaves in a database [3].

“Advances in image processing for detection of plant diseases” was proposed. In this study histogram matching is used to identify plant disease. In plants, disease appears on leaf therefore the histogram matching is done on the basis of edge detection technique and color feature. Layers separation technique is used for the training process which includes the training of these samples which separate the layers of RGB image into red, green, and blue layers and edge detection technique which detecting edges of the layered images. Spatial Gray-level Dependence Matrices are used for developing the color co-occurrence texture analysis method [4].

“Applying image processing technique to detect plant diseases” was proposed. In this study the author presented a methodology for early and accurately plant diseases detection, using artificial neural network (ANN) and diverse image processing techniques. As the proposed approach was based on ANN classifier for classification and Gabor filter for feature extraction, it gave better results with a recognition rate of up to 91%. An ANN based classifier classifies different plant diseases and uses the combination of textures, color and features to recognize those diseases [5].

"Leaf disease severity measurement using image processing" was proposed. This study has presented the triangle threshold and simple threshold methods. These methods are used to lesion region area and segment the leaf area respectively. In final step, categorization of disease is done by calculating the quotient of leaf area and lesion area. According to the research done, the given method is fast and accurate for calculating leaf disease severity and leaf area calculation is done by using threshold segmentation [6].

CHAPTER 3

WIRELESS MULTIMEDIA SENSOR NETWORK BASED PLANT DISEASE DETECTION

In agriculture practice, being able to detect plant diseases at their early stage can usually prevent major losses on the farmland yields. This work has been done by doing sampling inspection on the large farmland manually, which is a costly and demanding process. In recent years, the rapid development of Wireless Multimedia Sensor Network (WMSN) provides a new support to this task that has the potential of reducing the workload substantially. The wireless multimedia sensor network node is equipped with a low cost CCD camera and is able to take and send back images of its deployment location. After WMSN has been deployed on the farmland, the inspector only needs to distinguish crop images on the computer to obtain the information on crop growth.

Considering the resource constraints on WMSN like computation power, network bandwidth, energy consumption and the workload of each WMSN node, it is not a good idea to let every node to send back the image frequently. Therefore, if the inspection interval (sample frequency) is too long, plant disease may spread in large scale during the interval. To solve this dilemma, we propose a solution based on a plant disease detection program running on each node of the WMSN, which automatically inspects the newly taken plant images and determines whether the plant has the risk of infection. Under this mechanism, the WMSN can take plant photos at a higher frequency, but the amount of data to be transferred is reduced.

3.1 OVERVIEW OF PLANT DISEASE

Plant disease can be defined as the sum total of abnormal changes in physiological processes brought about by any biotic or abiotic factor or by a virus that ultimately threatens the normal growth and reproduction of a plant.

Plant diseases occur due pathogens such as bacteria, virus, fungi, oomycetes, nematodes, phytoplasmas, protozoa, and parasitic plants. Plants like all living organisms become diseased as a result of infection by living microbes and a few other organisms, and by exposure to adverse environmental factors. Plants have internal mechanisms of defense that protect them against diseases but, when defenses are insufficient, they become diseased. The occurrence and prevalence of plant diseases vary from season to season, depending on the presence of pathogen, environmental conditions, and the crops and varieties grown. Some plant varieties are particularly subject to outbreaks of diseases; others are more resistance to them.

Plant diseases interfere with the growth and cause damage to cultivated and naturally growing plants. The interference and damage often results in failure of plants to grow and produce or in destruction of parts or of total plants. Interference of plant diseases with the growth of and production by plants, and their damage and destruction of plants removes plants and their products from availability for food by humans and animals. It is estimated that, as a minimum, diseases destroy approximately 30-40% of the produce of cultivated plants grown annually by humans for food or feed. When the plant is suffering its functioning and development is disturbed, that is called a diseased plant.

3.1.1 Causes of plant diseases:

- Abiotic factors: - These are the resultants of deficiencies or excess of nutrients, light, moisture, aeration adverse soil condition or atmospheric condition. These are generally referred as diseases.
- Mesobiotic factors: - The causal agent is neither living thing nor non-living thing. The diseases caused by viroid and viruses or of this category.
- Biotic factors: - This category includes diseases caused by living/cellular organizations. Eukaryotes – fungi, protozoa, algae, nematode, parasites. Prokaryotes – mycoplasma, rickettsia, bacteria.

3.1.2 Classification of plant diseases:

The cultivated and wild plants are affected by various diseases. Each crop can be affected by a hundred or more plant diseases. Some pathogens affect only one specific variety of crop plant. Other pathogens affect several dozen or even hundreds of species of plants. The advantage of classifying diseases is that it is helpful to recognize the cause of the disease, which immediately suggests the probable method of development and spread of the disease and also possible control measures.

Plant diseases can be classified based on the following criteria: -

1. Infectious/biotic plant diseases which are caused by:

- Prokaryotes
- Fungi
- Viruses and viroids
- Nematodes, protozoa and by parasitic higher plants and parasitic algae.

2. Non-infectious or abiotic plant diseases which may be caused by:
    - Too low temperature or too high temperature.
    - Lack or excess soil moisture.
    - Lack or excess of light.
    - Lack of oxygen.
    - Air pollution.
    - Nutrient deficiencies.
    - Mineral toxicities.
    - Soil acidity or alkalinity.
    - Toxicity of pesticides.
    - Improper cultural practice.

3.1.3 Disease may be classified on the basis of:

- Host plant affected, such as cereals, millets, fruits, trees, and vegetables.
- Part of the plant affected such as root, stem, leaf, flower, and fruit.
- Symptoms produced in the host plants, such as wilt, blight, soft-rot, anthracnose, rust, smut, mildew and damping off.
- The mode of spread and severity of infection such as epiphytotic, endemic, sporadic, and pandemic.
- Causal organism / factors

3.1.4 Classification of plant diseases on the basis of spread and severity of infection:

- Endemic disease- It is constantly present in a moderate or severe form and it is confined only to a particular country or district, e.g. the Black-wart disease of potato caused by S*yncytium endobioticum* is endemic to Darjeeling. In plant pathology, this term is generally applied to simple interest diseases which are either indigenous or of ancient introduction.

- Epidemic / epiphytotic disease- Epidemic disease usually occurs widely causing a huge loss in a country, periodically in a destructive form because of the presence of the pathogen and the favorable environmental factors responsible for the development of the disease occur only periodically in a certain country or a state or a district, e.g. Late blight of potato resulted in Irish Famine in Ireland in 1845; and Leaf-blight of rice caused a famine in West Bengal.
- Sporadic disease- It is applied to a disease which occurs at very regular intervals involving few plants at a time in widely located regions causing little economic loss e.g. Angular leaf spot of cotton and blotch disease of cucumber.
- Pandemic diseases- Pandemic outbreak is an epidemic which occurs over vast and extensive areas causing severe losses. These may occur all over the world and result in mass mortality e.g. most of viral diseases.

3.1.5 Major diseases that affects the plants:

- Black spot.
- Botrytis blight.
- Leaf spot.
- Powdery mildew.
- Rust.

3.2 OVERVIEW OF WIRELESS MULTIMEDIA SENSOR NETWORKS:

Wireless multimedia sensor networks(WMSNs) have emerged and shifted the focus from the typical scalar wireless sensor networks to networks with multimedia devices that are capable to retrieve video, audio, images, as well as scalar sensor data. WMSNs are able to deliver multimedia content due to the availability of the inexpensive CMOS cameras and microphones coupled with the significant progress in distributed signal processing and multimedia source coding techniques. The field of Wireless Sensor Networks (WSNs) is retrieving much attention in the networking research community and as an interdisciplinary field of interest. WSNs are becoming more low-cost, low power, multi-functional, and viable due to the advances in micro-electro-mechanical systems (MEMS), low power and highly integrated digital electronics, and proliferation of wireless communication.

Wireless Sensor Networks typically consists of large number of intelligent battery-powered sensor nodes with sensing, processing and wireless communicating capabilities. WSNs have wide and varied applications such as real time tracking of objects, monitoring of environmental conditions, monitoring of health structures, and preparing a ubiquitous computing environment. Wireless Multimedia Sensor Network (WMSNs) is a network of wirelessly interconnected sensor nodes equipped with multimedia devices, such as cameras, and microphones, and capable to retrieve video and audio streams, still images, as well as scalar sensor data.it promises a wide range of potential applications in both civilian and military areas which require audio and video information such as surveillance sensor networks, law-enforcements reports, traffic control systems, advanced health care deliver, automated assistance to elderly telemedicine, and industrial process control. In these applications multimedia support has the potential of enhancing the level of information collected, enlarging the range of coverage, and enabling multiresolution views.

CHAPTER 4

PLANT DISEASE DETECTION SYSTEM

Efficient and novel Disease Detection System is used to detect the diseases in leaves and extract the features for classification. The classification process is carried out at the monitoring site where an expert analyzes the disease and provide solution to farmers. The suggested system consists of five phases: image acquisition, image preprocessing, image segmentation, feature extraction, analysis, and classification.

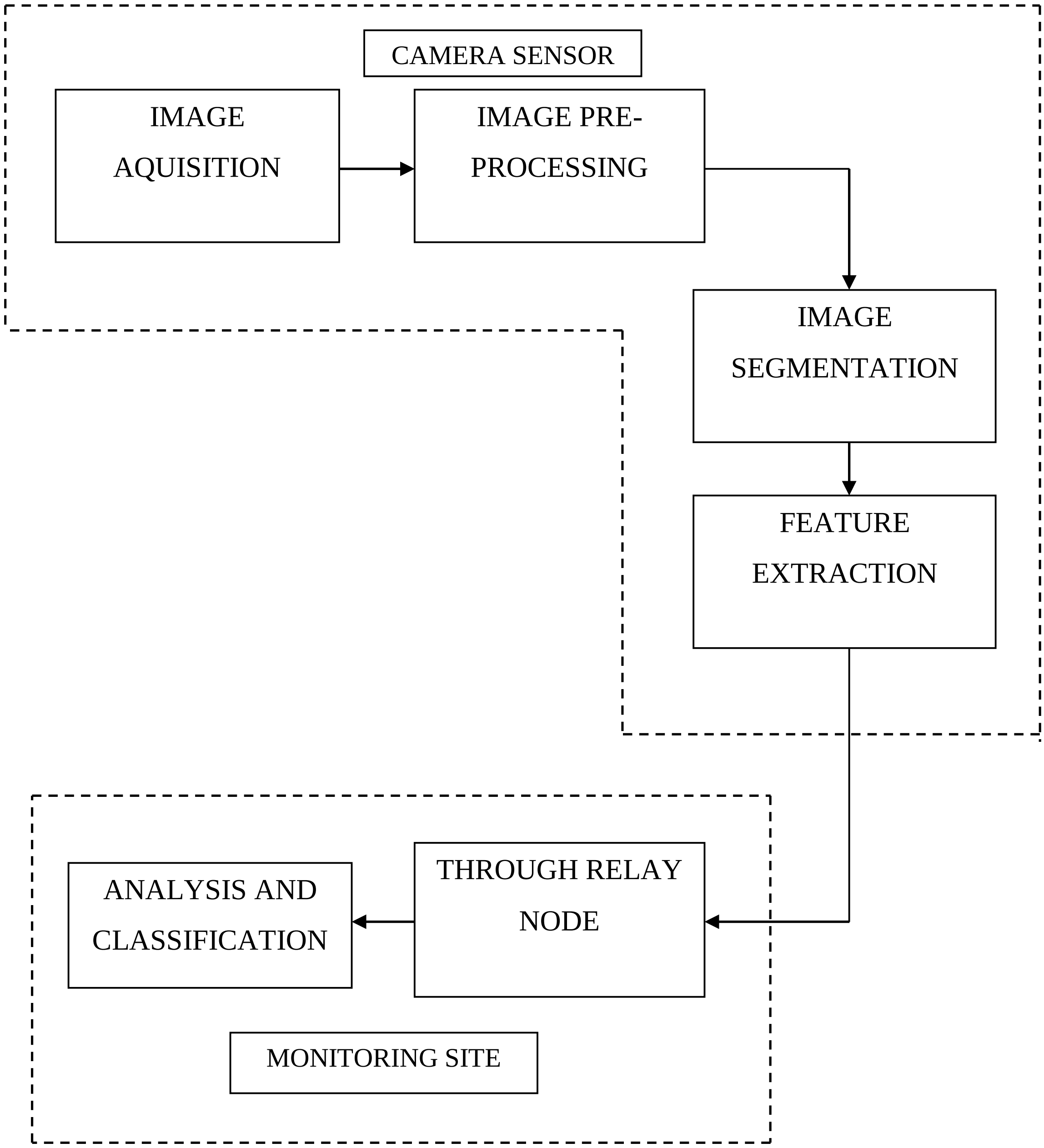

Figure 4: Plant disease detection for farmers using WMSNs.

4.1 IMAGE ACQUISITION:

Image acquisition is the very first step that requires capturing an image with the help of a digital camera. After the image is obtained various methods of processing can be applied to the image to perform the many different vision tasks.

4.2 IMAGE PRE-PROCESSING:

Preprocessing of input image to improve the quality of image and to remove the undesired distortion from the image. Clipping of the leaf image is performed to get the interested image region and then image smoothing is done using the smoothing filter. To increase the contrast Image enhancement is also done.

Image pre-processing involves removing low frequency background noise, normalizing the intensity of individual particles images, removing reflection and masking portion of images. It is the technique for enhancing data images prior to computational processing. Pre-processing required for shadow removal, image correction. Shadow removal is very important because shadow may disturb segmentation and feature extraction. Initially, captured pictures are resized to a fixed resolution therefore on utilize the storage capacity or to reduce the process burden within the later process. Noise is inevitable throughout image acquisition or transmission. Noise would disturb the segmentation and therefore the feature extraction of disease spots. So that they should be removed or weakened before any further image analysis by applying an appropriate image filtering operation.

4.3 IMAGE SEGMENTATION:

Image segmentation is considered as an important basic operation for meaningful analysis and interpretation of image acquired. It is a critical and essential component of an image analysis and/or pattern recognition system, and is one of the most difficult tasks in image processing, which determines the quality of the final segmentation. Colour of an image can carry much more information than grey level. There probably is no “one true” segmentation acceptable to all different people and under different psychophysical conditions. There are many methods for image segmentation. These methods can be broadly classified into seven groups: Histogram thresholding, clustering (Fuzzy and Hard), Region growing, region splitting and merging, Edge-based, Physical model- based, Fuzzy approaches, and Neural network and GA (Genetic algorithm) based approaches.

4.4 FEATURE EXTRACTION:

It is the process of generating the features to be used in selection and classification. Color, Morphology and Texture feature vectors are used for feature extraction. Some of the texture features.

- Contrast: - It is an important factor in any subjective evaluation of image quality. It is created by difference in luminance created from two adjacent surfaces. In other words, contrast is the difference in visual properties that makes an object distinguishable from other objects in the background. In visual perception contrast is determined by the difference in the color and brightness of the object with other objects.
- Energy: - Energy is defined based on a normalized histogram of the image. Energy shows how the grey levels are distributed. When the number of grey levels is low then energy is high.
- Entropy: - Image entropy is a quantity which is used to describe the 'business 'of an image i.e. the amount of information which must be coded for, by a compression algorithm. An image that is perfectly flat will have an entropy of zero.
- Homogeneity: - Homogeneity is computed from image grey levels to facilitate the classification.
- Correlation: - Correlation is a basic operation that is performed to extract information from images. It is a simplest operation that can be performed on the image, but it is extremely useful. Digital image correlation and tracking is an optical method that employs tracking and image registration techniques for accurate 2D and 3D measurements of changes in images. This method is often used to measure fulfilled displacement and strains.

4.5 ANALYSIS AND CLASSIFICATION:

Support Vector Machine (SVM) algorithm is used for training and classification. Support vector machine find out the linear separating hyper plane that maximize margin and can be used for classification. SVM uses a nonlinear data into higher dimensions. Dimension boundary separate tuples from one class to another. The training time of Support vector machine is slow however they're highly accurate. After applying SVM, clusters will classify into 2 classes with labels disease infected images and non-infected images. Infected image class consist leaf images affected by bacterial blight and non-infected image class includes healthy leave images.

CHAPTER 5

METHODOLOGY

The system consists of five phases: image acquisition, image pre-processing, image segmentation, feature extraction, analysis, and classification.

5.1 IMAGE ACQUISITION:

In this phase, images of the diseased leaves are captured using a camera sensor node. In order to reduce the memory and energy complexity, the camera is triggered only when the color change in leaves is detected. Once the image is captured it undergoes pre-processing.

5.2 IMAGE PRE-PROCESSING:

The acquired image is pre-processed to enhance the quality of the image for efficient segmentation. In the pre-processing phase the image is resized and the contrast of the image is enhanced. The RGB to HSI (Hue Saturation Intensity) transformation is carried out on the enhanced image as it can be easily segmented from the HSI transformed image rather than the RGB image.

5.3 IMAGE SEGMENTATION:

In the segmentation phase, a simple and novel mean based thresholding strategy (MTS) is proposed to segment the diseased part of the leaves. MTS is designed using the HSI transformed image and the pixels of the transformed image are compared with the threshold to segment the affected part. The procedure for designing the threshold is as shown:

Input: H image

Output: threshold (T_{MTS})

Procedure:

Step 1: Compute the maximum of the pixels in the H image (M_H)

$$M_{H} = \max (H) \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Step 2: Compute the mean of the H image (μ_H)

$$\mu_H = \frac{\sum_{o=0}^{L}\sum_{P=0}^{N} H(o,p)}{L*N} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

Step 3: Compute the threshold using equation (1)

$$T_{MTS} = \frac{M_H}{\mu_{H*10}} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

The pixels of the H image are compared with the threshold shown in Eq. (3) to segment the diseased part of the leaves. Feature extraction is carried out after the segmentation phase.

5.4 FEATURE EXTRACTION:

In DDS feature extraction is carried out based on the texture analysis. The Grey Level Co-occurrence Matrix (GLCM) is used to obtain the statistical texture features. Contrast, energy, homogeneity, entropy and correlation are some of the texture based features extracted from the segmented image. The GLCM matrix is used for the H image and the features and its corresponding equations are shown in the above design of mean based threshold, where P (i, j) denotes the elements of the GLCM matrix and K denotes the number of grey levels in the image.

FEATURES	EQUATIONS
Contrast	$\sum_{i,j=0}^{K-1} \lvert i-j \rvert^2 P(i,j)$
Energy	$\sum_{i,j=0}^{K-1} \mathrm{P(i,j)}^2$
Entropy	$-\sum_{i,j=0}^{K-1} P(\mathrm{i,j}) \log \mathrm{P(i,j)}$

Homogeneity	$\sum_{i,j=0}^{K-1} \frac{P(i,j)}{(1+\|i-j\|)^2}$
Correlation	$\sum_{i.j=0}^{K-1} \frac{(i-\mu i)(j-\mu j)P(i,j)}{\sigma_i \sigma_j}$

Table 1: Texture features extracted from the segmented image.

5.5 CLASSIFICATION OF DISEASES:

The features based on texture are transmitted through relay nodes to the monitoring site where the classification is carried out using the SVM classifier. SVM is commonly used for classification process and belongs to the group of supervised learning.

Supervised learning makes use of the training dataset to predict the testing dataset. SVM yields high accuracy when used with texture features. SVM makes use of the linear kernel function to classify the healthy leaves and diseased leaves.

The suggested work can be applicable for detecting various kinds of disease in different plants. Some of them are listed below:

- Fungal disease.
- Sun burn disease.
- Bacterial leaf spot disease.
- Scorch disease.

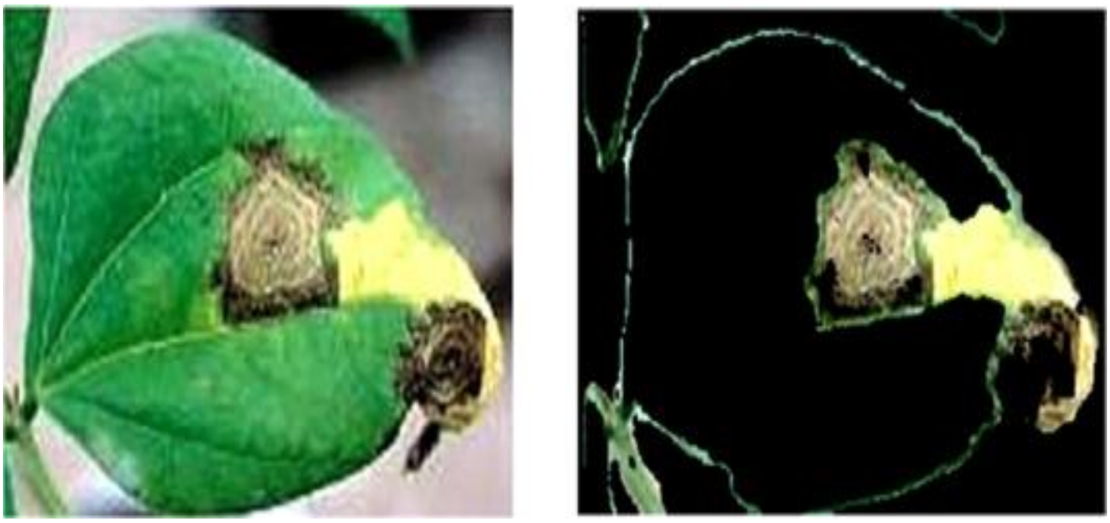

Figure 5: Input and output image of beans leaf and output diseases is fungal disease

Figure 6: Input and output image of lemon leaf and output diseases is sun burn disease

Figure 7: Input and output image of rose leaf and output diseases is bacterial leaf spot

Figure 8: Input and output image of banana leaf and output diseases is early scorch disease.

CHAPTER 6

RESULTS AND DISCUSSION

The suggested disease detection and classification system is simulated using MATLAB environment in Windows 10 PC. For simulation, diseased leaves of the pomegranate plant are considered. Database is created with 20 images for training and 10 images are used for testing. The diseases such as Anthracnose, Alternaria Alternata and Cercospora leaf spot in pomegranate leaves are considered for demonstration. In the image acquisition phase the test images are taken as input and pre-processed by resizing the image to 256×256. To enhance the quality of the image, contrast enhancement technique is adopted. After enhancing the quality, the image is transformed from RGB to HSI color space. The image is segmented using the proposed MTS threshold strategy. The threshold is computed using Eq. (3) and the pixels of the H image are compared with the threshold to segment the diseased part in the leaves. After segmentation, the texture based features such as contrast, energy, homogeneity, entropy and correlation are computed using Eqs. listed in the table 1. GLCM matrix for H image is used to analyze the texture based features. These features are transmitted through the TelosB nodes to the monitoring site. SVM classifier is used at the receiver side in a PC which has the database with trained images for classification.

Figures 9, 10 and 11 shows the input test images, preprocessed images, and segmented images of the diseased pomegranate leaves.

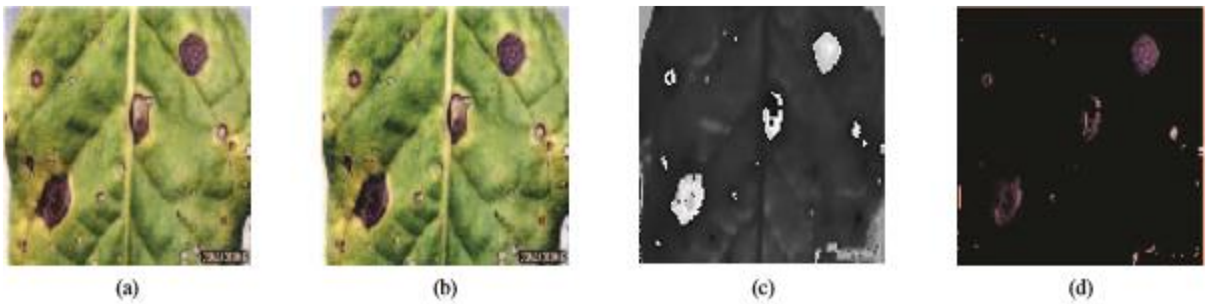

Figure 9: Pomegranate leaves identified as Alternaria Alternata disease. (a) Test image. (b) Contrast enhanced image. (c) HSV transformed image. (d) Segmented image using proposed MTS.

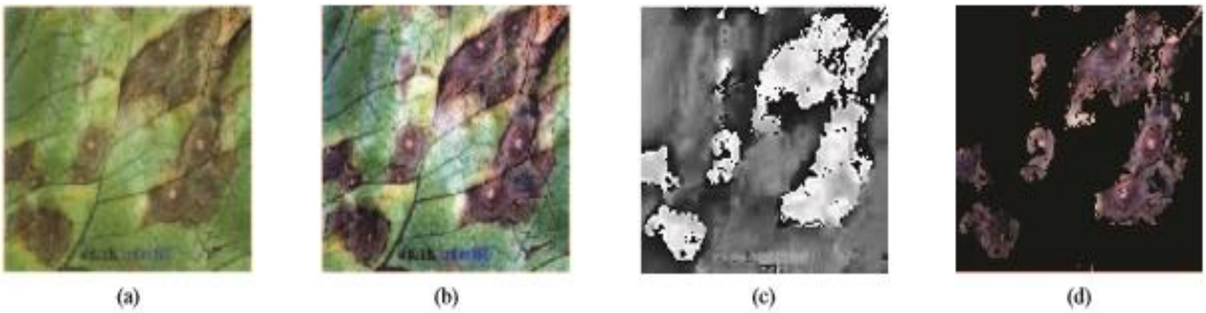

Figure 10: Pomegranate leaves identified as Anthracnose disease. (a) Test image. (b) Contrast enhanced image. (c) HSV transformed image. (d) Segmented image.

Figure 11: Pomegranate leaves identified as Cercospora leaf spot disease. (a) Test image. (b) Contrast enhanced image. (c) HSV transformed image. (d) Segmented image using proposed MTS.

The performance suggested work is evaluated in terms of accuracy of the system which is compared with the existing work reported in [8]. The transmission energy is also computed for transmitting the features through TelosB nodes which is compared with the raw frame transmission. The accuracy (A) of the system is calculated using Eq. (4) [8].

$$A = \frac{\text{Number of correct classification}}{\text{Total number of test images}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

The accuracy of the system is tabulated for different diseases in Table 2. MTS is compared with the well-known k-means clustering process based segmentation.

Leaf diseases	Detection accuracy (%)	
	SVM with k-means [7]	SVM with MTS
Alternaria Alternata	98.48	100
Anthracnose	96.7742	98.3871
Cercospora leaf spot	96.7742	96.7742

Table 2: Comparison of suggested work with existing work in terms of accuracy.

From Table 2 it is observed that the suggested system achieves 98% accuracy on an average and it is better compared with the SVM with k-means clustering process reported in [7].

Figure 12 shows the overall accuracy achieved using MTS with SVM classifier. The transmission energy is calculated by transmitting the features in real time through TelosB nodes. TelosB nodes [8] operate under Contiki OS platform [9]. The power trace tool [10] in Contiki OS platform is used to calculate the transmission energy in nodes. The practical energy for transmitting a bit (Et) is calculated to be 0.27 μJ [11]. The transmission energy for an image (EI) is calculated using Eq. (8) EI = n∗Et (8) where 'n' denotes the number of bits to be

Input	**Transmission energy (mJ)**	
	Raw image	Features
Test image	141	0.011

Table 3: Comparition of transmission energy for raw image and features extracted.

Table 3 shows the comparison of transmission energy between raw image transmission and feature transmission. From the table, it is observed that the reduction in transmission energy is around 99%. Hence the suggested system yields better accuracy with less transmission energy which indicates that the feature transmission is preferred over raw image for resource constraint environment like WMSN.

The overall accuracy of the system is shown in the figure.12.

Figure 12: The overall accuracy of system.

ADVANTAGES

1.Use of estimators for automatic Initialization of cluster centers so there is no need of user input at the time of segmentation.

2.The detection accuracy is enhanced with proposed algorithm.

3.The suggested system is fully automatic while existing methods require user input to select the best segmentation of input image.

4.It also provides environment friendly recovery measures of the identified disease.

LIMITATIONS

1.The implementation still lacks in accuracy of result in some cases. More optimization is needed.

2.Priori information is needed for segmentation.

3.Database extension is needed in order to reach the more accuracy.

4.Very few diseases have been covered. So, work needs to be extended to cover more diseases.

5.The possible reasons that can lead to misclassifications can be as follows: disease symptoms vary from one plant to another, features optimization is needed, more training samples are needed in order to cover more cases and to predict the disease more accurately.

CONCLUSION

This report provides the overall information about different plant diseases. Plant disease detection is important for agricultural applications to increase the cultivation yield. WMSN with camera capability is used to capture the diseased leaves in the farm and process it to extract the features. These features are transmitted to the monitoring site through relay nodes. At the monitoring site the diseases are classified based on the extracted features. Based on the classified disease the farmers are given suggestions. A novel and simple segmentation process based on threshold is proposed to segment the diseased part and the features are extracted using GLCM matrix. The SVM classifier is used to classify the disease using linear kernel function. The proposed threshold strategy performs better compared to k-means clustering technique with less complexity is discussed in this report. The extracted features are transmitted through Telos B nodes and the transmission energy can be analyzed in real time. The transmission energy can be reduced to 99% on an average compared to raw frame transmission.

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