Intelligent Plant Disease Detection System Using Wireless Multimedia Sensor Network

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Abstract—**Agricultural field plays a vital role in the development of India. Farmers encounter great difficulties in detecting and controlling plant diseases. Thus, it is of great importance to diagnose the plant diseases at early stages so that appropriate and timely action can be taken by the farmers to avoid further losses. Plant disease detection is important for agricultural applications to increase the cultivation yield. Detection of plant disease through some automatic technique is beneficial as it reduces a large work of monitoring in big farms of crops, and at very early stage itself it detects the symptoms of diseases i.e. when they appear on plant leaves. Wireless multimedia sensor networks (WMSNs) attracts significant attention in the field of agriculture where disease detection plays an important role. Due to the limitations of WMSN, it is necessary to design a simple system which can provide higher accuracy with less complexity. In this paper a novel disease detection system (DDS) is proposed to detect and classify the diseases in leaves. Statistical based thresholding strategy is proposed for segmentation which is less complex compared to k-means clustering method. The features extracted from the segmented image will be transmitted through sensor nodes to the monitoring site where the analysis and classification is done using Support Vector Machine Cluster classifier. The performance of the DDS has been evaluated in terms of accuracy and is compared with the existing k-means clustering technique. This paper provides an overall accuracy of around 98%. The transmission energy is also analyzed in real time using Telos B nodes.**

keywords—Wireless multimedia sensor networks, disease detection, SVM, threshold strategy, agriculture.

I. INTRODUCTION

India is developing country. During this development, contribution of agricultural field is major. Therefore, in field of agriculture, detection of disease in plants plays an important role. The existing method for plant disease detection is simply naked eye observation by experts through which identification and detection of plant diseases is done. As consulting experts 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. In plants, some general diseases seen are brown and yellow spots, early and late scorch, and others are fungal, viral and bacterial diseases.

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. The camera nodes placed in the farm captures the image of the plants and processes it to detect and segment the disease. 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. 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.

In this paper, a novel disease detection system (DDS) detects the diseases in leaves and extract the features. The main contribution of this work 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.

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

II. LITERATURE 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].

III. 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.

Plant diseases occur due pathogens such as bacteria, virus, fungi, oomycetes, nematodes, phytoplasma, 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 defence that protect them against diseases but, when defences 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.

IV. PLANT DISEASE DETECTION SYSTEM

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

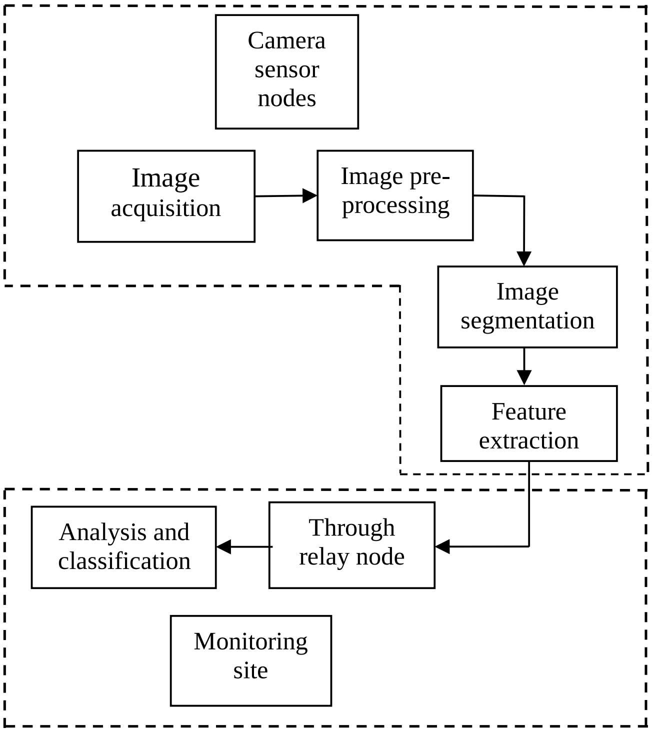

Figure 2: Plant disease detection for farmers using WMSNs.

A. 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.

B. 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.

C. 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. Color 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.

D. 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. Contrast is the difference in visual properties that makes an object distinguishable from other objects in the background.
- 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.

E. ANALYSIS AND CLASSIFICATION:

Support Vector Machine (SVM) algorithm is used for training and classification. Support vector machine finds out the linear separating hyper plane that maximize margin and can be used for classification. 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

V. METHODOLOGY

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

A. 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.

B. 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.

C. 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 (TMTS)
Procedure:
Step 1: Compute the maximum of the pixels in the H image (MH)
MH = max (H) ……………………………………(1)
Step 2: Compute the mean of the H image (μH)

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

Step 3: Compute the threshold using equation (1)

$$T_{MTS} = \frac{M_H}{\mu_{H*10}} \quad \text{……………………………………………(3)}$$

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.

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

Table 1: Texture features extracted from the segmented image.

E. 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.

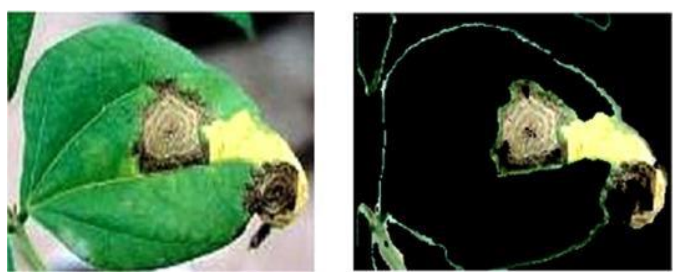

Figure 3: Input and output image of beans leaf and output diseases is fungal disease

Figure 4: Input and output image of lemon leaf and output diseases is sun burn disease

Figure 5: Input and output image of rose leaf and output diseases is bacterial leaf spot

Figure 6: Input and output image of banana leaf and output diseases is early scorch disease.

VI. 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

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.

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.

Following figures shows the input test images, preprocessed images, and segmented images of the diseased pomegranate leaves.

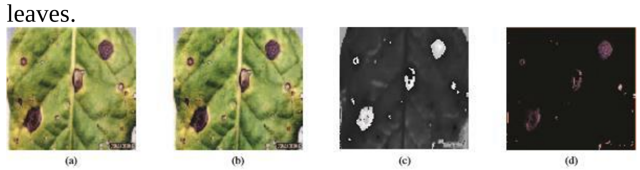

Figure 7: Pomegranate leaves identified as Alternaria Alternata disease. (a) Test image. (b) Contrast enhanced image. (c) HSV transformed image. (d) Segmented image using proposed MTS.

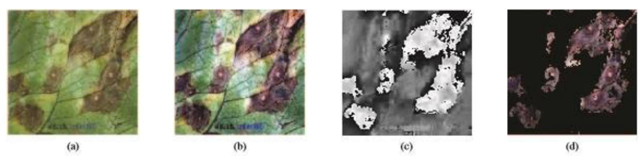

Figure 8: Pomegranate leaves identified as Anthracnose disease. (a) Test image. (b) Contrast enhanced image. (c) HSV transformed image. (d) Segmented image.

Figure 9: 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. 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).

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

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.

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.

The overall accuracy achieved using MTS with SVM classifie as shown in the figure 10. The transmission energy is calculated by transmitting the features in real time through TelosB nodes. TelosB nodes operate under Contiki OS platform. The power trace tool 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. The transmission energy for an image (EI) is calculated using Eq. (8) EI = n∗Et where 'n' denotes the number of bits to be

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

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

The comparison of transmission energy between raw image transmission and feature transmission is shown in the table 3. 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 10.

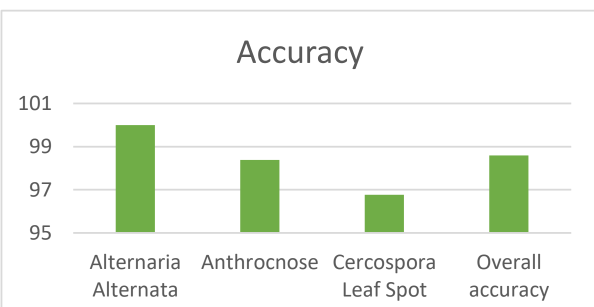

Figure 10: The overall accuracy of system.

VII. CONCLUSION

This paper 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 paper. 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.

REFERENCES

1. Mrunmayee Dhakate and A. B. Ingole "Diagnosis of pomegranate plant diseases using neural network", In Computer Vision, Pattern Recognition, Image Processing and Graphics (NCVPRIPG), 2015 Fifth National Conference on, IEEE, pp. 1–4, 2015.

2. Badnakhe Mrunalini, Prashant R. Deshmukh "An application of K-means clustering and artificial intelligence in pattern recognition for crop diseases", Int Conf Adv Inf Technol, 20 (2011) 2011 IPCSIT.

3. R. Newlin Shebiah, S. Ananthi, S. Vishnu Varthini "Detection of unhealthy region of plant leaves and classification of plant leaf diseases using texture features", S. Arivazhagan Agric Eng Int CIGR, 15 (1) (2013), pp. 211-217

4. Smita Naikwadi, Niket Amoda "Advances in image processing for detection of plant diseases", Int J Appl Innov Eng Manage, 2 (11) (2013).

5. Anand H. Kulkarni, R.K. Ashwin Patil **"**Applying image processing technique to detect plant diseases", Int J Mod Eng Res, 2 (5) (2012), pp. 3661-3664

6. Sanjay B. Patil, *et al "*Leaf disease severity measurement using image processing", Int J Eng Technol, 3 (5) (2011), pp. 297-301

7. Manisha Bhange and H. A. Hingoliwala, "Smart farming: Pomegranate disease detection using image processing," Procedia Computer Science, vol. 58, pp. 280–288, 2015.

8. Vijai Singh and A. K. Misra, "Detection of plant leaf diseases using image segmentation and soft computing techniques," Information Processing in Agriculture, 2016.