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Low Complexity Design for WSN Based Plant Monitoring System

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Abstract - *Wireless Sensor Networks (WSNs) consist of multiple unassisted embedded devices which process and transmit data collected from different on-board physical sensors. There are several applications in WSN such as agriculture, industrial monitoring, etc.,. In agriculture, an efficient wireless monitoring system design the sensor and camera based wireless network for regularly monitoring of the plant conditions. Plant monitoring system provides environmental and controlling services for field which leads to plant growth in an optimal status. Diseases are readily recognized by their symptoms. Image processing and computer vision technology are very beneficial to the agricultural industry. Sensor networks collect data from different physical sensors like temperature, humidity, and water level. They are more potential and more important to many areas in agricultural technology. An integration of plant monitoring with image processing sensor networks using Field Programmable Gate Array (FPGA) based control is the new method. The results show the advantages of new technology in terms of reduced power consumption and area reduction. It can help the farmer to detect the plant conditions faster. The wireless system also improves the farmer-field-expert relationship.*

Key Words: Wireless Sensor Network, Wireless Camera, Plant Monitoring, Image Processing, Field Programmable Gate Array.

1. INTRODUCTION

Plant disease detection and field monitoring plays an important key role in successful cultivation. Plant diseases cause significant reduction in both quality and quantity of agricultural products. The technology utilization would be allowed for remote measurement of factors such as plant growth condition including temperature, humidity, atmospheric pressure, soil moisture, water level. The wireless system also improves the conveniences of monitoring services.

Sensor Networks have been deployed for a wide variety of applications and awareness has increased with regards to implement technology into an agricultural environment. Monitoring crops for detecting environmental conditions and disease detection is an important role in successful cultivation. Manual collection of data results in variations when compared to the incorrect measurement taken from the field. This can cause complications in controlling any important factor. The visual analysis of experts is the major practical approach. So we have to look for fast, automatic and less expensive accurate method for continuous monitoring of agricultural field. Wireless sensor network can reduce this effort and time required for monitoring an agricultural environment. Absence of the farmer-field-expert integration results in reduction of plant growth. Hence to meet these challenges, integrated real time plant investigation is proposed. Plant monitoring system using WSN represents a set of network applications with huge possible benefits for the farmers and society as a whole.

2. PROPOSED PLANT MONITORING SYSTEM DESIGN

The new architecture involves integration of sensor network and high definition camera in the field to effectively connect farmers-field-experts instead of farmers or experts directly accessing the field is shown in figure 1. The need to process the field information in real time monitoring leads to this implementation in hardware level. FPGAs are used in modern agriculture application. Field conditions are continuously monitored by the wireless sensor and camera equipment. Sensors are used to provide the current status of environmental conditions. Plant leafs are observed by image feature extraction and processing algorithm.

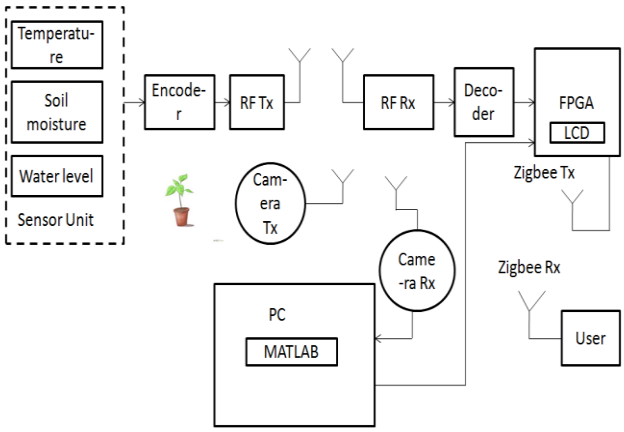

Fig-1: Block diagram of plant monitoring system design

The proposed approach starts first by image feature extraction and processing technique. Anthracnose and Black spots are plant diseases.

Anthracnose: Anthracnose is a fungal disease. The initial symptoms of anthracnose are characterized by small water soaked brownish spots in large numbers. Anthracnose disease attacks all plant parts at any growth stage like leaves, stems, and fruits. Symptoms are most visible on leaves, ripe fruits and stem.

Black Spot: Black spot is a fungal disease. It can attack any plant with fleshy leaves and stems. It starts with tiny black spots on leaves, no bigger than a pinhead. As the fungus develops, those black spots on leaves are ringed with yellow. Soon the entire leaf turns yellow and falls.

3. ALGORITHMS AND STATISTICAL ANALYSIS

In image feature extraction and processing, various kinds of clustering methods, classifications are available. K-Means clustering and Support Vector Machine algorithms are used in this paper.

3.1 Algorithms

1.K-Means clustering: Image segmentation refers to the process of clustering the pixels. K-Means clustering is a technique which aims to partition n observations into K clusters in which each observation belongs to the cluster with nearest mean. Where, K is the number of clusters in the segmented image. The clustering is carried out based on the L*a*b colors present in an image.

2.Support Vector Machine (SVM): The support vector machine is superior of all machine learning algorithms. SVM employs optimization algorithms to locate the optimal boundaries between classes. The optimal boundaries should be generalized to unseen samples with least errors among all possible boundaries separating the classes, therefore minimizing the confusing between classes. The inductive principle behind SVM is structural risk minimization (SRM). The risk of learning machine (R) is bounded by the sum of the empirical risk estimated from training samples (R_{emp}) and a confidence interval (Ψ): $R \le R_{emp} + \Psi$. A separating hyper plane refers to a plane in a multi-dimensional space that separates the data samples of two classes.

3.2 Statistical Analysis

Feature extraction is performed on sub-images to extract the texture size and shape. The most famous feature extraction techniques are presented based on the Grey Level Co-occurrence Matrix (GLCM). It is a good approach for characterizing the texture and feature extraction techniques. Easy to implement and give exact texture.

The Color Co-occurrence Matrix (CCM) are then normalized using the Eq. (1) given below, where P (i, j, 1, 0) represents the intensity co-occurrence matrix.

$$p(i,j) = \frac{p(i,j,1,0)}{\sum_{i=0}^{N_g-1}\sum_{j=0}^{N_g-1} p(i,j,1,0)} \quad (1)$$

Where Ng is the total number of intensity levels.

Marginal probability matrix is given in Eq. (2),

$$p_x(i) = \sum_{j=0}^{N_g-1} p(i,j) \quad (2)$$

Sum and difference matrices are given in Eq. (3),

$$p_{x+y}(k) = \sum_{i=0}^{N_g-1}\sum_{j=0}^{N_g-1} p(i,j) \quad (3)$$

Where, k=I+j; for k=0,1,2 ..... 2(Ng-1)

$$p_{x-y}(k) = \sum_{i=0}^{N_g-1}\sum_{j=0}^{N_g-1} p(i,j) \quad (4)$$

Where, k=|I-j|; for k=0,1,2 ..... 2(Ng-1)

P(i,j) = the image attribute matrix and

Ng = total number of attribute levels.

Texture features:

The angular moment (I1) is given in Eq. (5), a measure of the image homogeneity.

$$I_1 = \sum_{i=0}^{N_g-1}\sum_{j=0}^{N_g-1} [p(i,j)]^2 \quad (5)$$

The mean intensity level (I2) is given in Eq. (6), a measure of image brightness derived from the co-occurrence matrix.

$$I_2 = \sum_{i=0}^{N_g-1} i p_x(i) \quad (6)$$

Variation of image intensity is identified by the variance textural feature (I3) is given in Eq. (4.7),

$$I_3 = \sum_{i=0}^{N_g-1} (i - I_2)^2 p_x(i) \quad (7)$$

Correlation (I4) is a measure of intensity linear dependence in the image using Eq. (8),

$$I_4 = \frac{\sum_{i=0}^{N_g-1}\sum_{j=0}^{N_g-1} ij p(i,j) - I_2{}^2}{I_3} \quad (8)$$

The produce moment (I5) is analogous to the covariance of the intensity co-occurrence matrix using the Eq. (9),

$$I_5 = \sum_{i=0}^{N_g-1}\sum_{j=0}^{N_g-1}(i - I_2)(j - I_2)p(i,j) \quad \textbf{(9)}$$

Contrast of an image can be measures by the inverse difference moment (I6) using the Eq. (10),

$$I_6 = \sum_{i=0}^{N_g-1}\sum_{j=0}^{N_g-1}\frac{p(i,j)}{1+(i-j)^2} \quad \textbf{(10)}$$

The entropy feature (I7) is a measure of the amount of order in an image, and is computed as given in the Eq. (11),

$$I_7 = \sum_{i=0}^{N_g-1}\sum_{j=0}^{N_g-1}p(i,j)\ln p(i,j) \quad \textbf{(11)}$$

The sum and differences entropies (I8 and I9) cannot be easily interreted, yet low entropies indicates high levels of order. I8 and I9 can be computed as given in the Eq. (12) and (13),

$$I_8 = \sum_{k=0}^{2(N_g-1)}p_{x+y}(k)\ln p_{x+y}(k) \quad \textbf{(12)}$$

$$I_9 = \sum_{k=0}^{N_g-1}p_{x-y}(k)\ln p_{x-y}(k) \quad \textbf{(13)}$$

4. PROCESSING FLOW OF FEATURE EXTRACTION AND PROCESSING

The overall concept for image feature extraction and processing technique design flow is shown in figure 2. Image processing techniques are applied to extract useful features that are necessary for further analysis of these images.

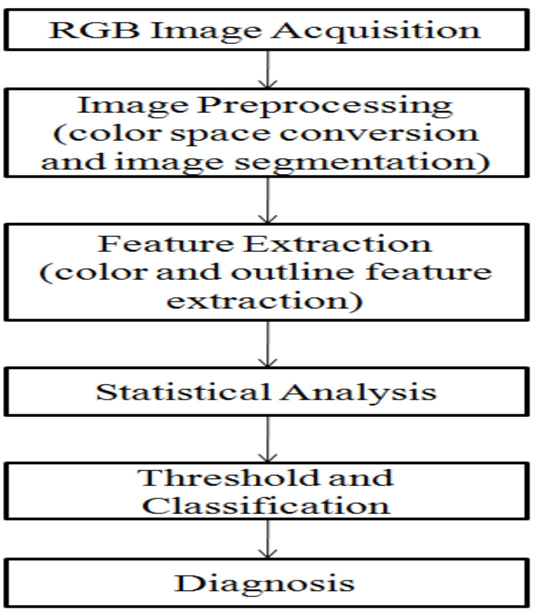

Fig-2: Processing flow of feature extraction and processing

Leaf images are taken from an environment. The acquired image is Red-Green-blue (RGB) space. In second step, RGB format converted to gray scale and image segmentation was performed. K-Means clustering is used for image segmentation. In third step, color and outline features of leafs are extracted. In fourth step, a feature of normal leaf is compared with disease infected leaf with the help of statistical analysis. In fifth step, gray scale image is converted into binary image and Support Vector Machine (SVM) is used for classification. Either Anthracnose or Black spot category is identified in this step.

Finally, percentage and grading of affected area is calculated. It diagnosis the grading of the disease depending upon the amount of the infected area in leaf. The percentage of affected area is calculated using,

Percentage = (Affected area/Total area) * 100 (14)

Where,

Affected area = Number of black spots count

Total area = Total size of leaf

The affected area is calculated by counting number of black spots over total area on leaf. The grading is performed based on percentage of affected area, whether image sample is normal, partially affected, moderately affected or unhealthy as shown below:

- <1% affected area = Normal
- ≤25% affected area = Partially affected
- ≤50% affected area = Moderately affected
- >50% affected area = Unhealthy

5. SIMULATION RESULTS AND OBSERVATIONS

A software routine was written in MATLAB that would be take in .mat files representing the training and test data, test data, train the classifier using the ‘train files’, and then use the ‘test file’ to perform the classification task on the test data. Consequently, a MATLAB routine would load all the data files and make modifications to the data according to the proposed model chosen. Demonstrate the proposed approach with a picture of banana leaf is shown in figure 3.

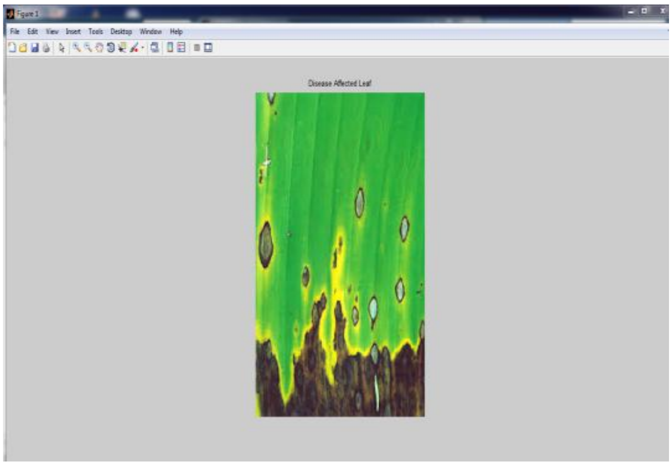

Fig-3: Input image of disease infected leaf

A clustered image of disease infected leaf is shown in figure is shown in figure 4.

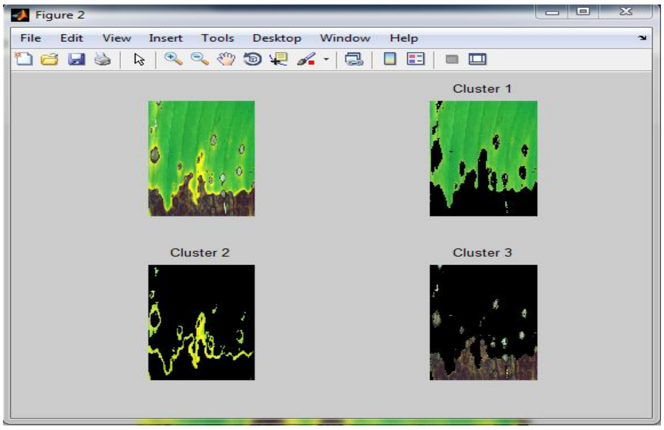

Fig-4: Clustered images of disease infected leaf

Enter the cluster number which containing disease infected leaf part to identify the binary form of clustered image is shown in figure 5.

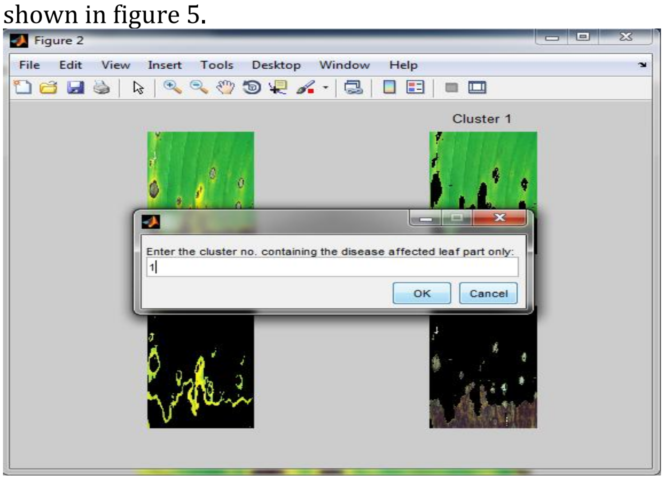

Fig-5: Infected leaf cluster identification

Binary of clustered image is shown in figure 6.

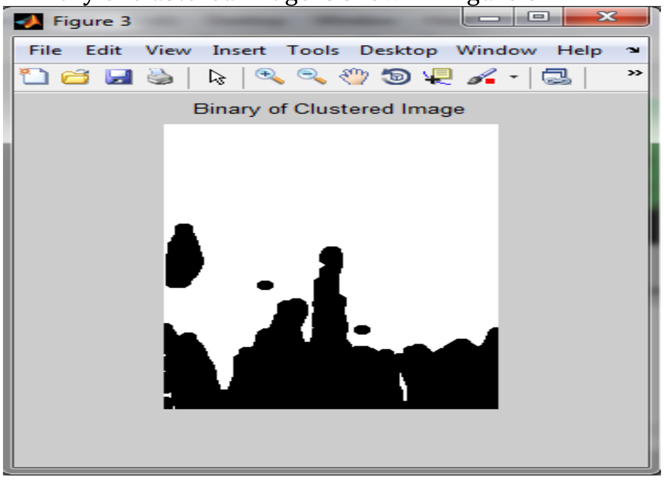

Fig-6: Binary of clustered image

Estimation of percentage of affected area and grading is shown in figure 7.

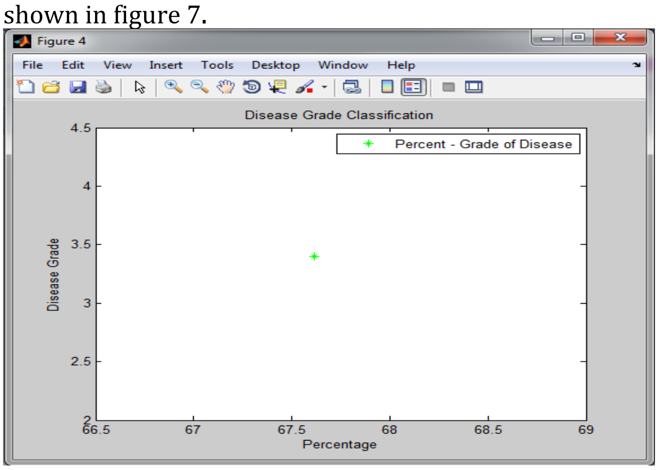

Fig-7: Estimation of percentage and grading

Observation

Image processing is performed in input image. The leaf disease is categorized as Black spot. Percentage of affected area is calculated by the Eq. (14), as 67.7% is shown in figure 7. So grading of the leaf is unhealthy.

6. CONCLUSION

In this paper an image feature extraction and processing approach is proposed and used for disease detection. We test our program on two diseases which effect on the plants such as Anthracnose and Black spot. Our experimental results shown that the proposed approach can support accurate and automatic detection of disease and percentage of affected area. Further investigation is going on for the obtained simulation results.

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