Plant Disease Detection using Image Processing and IoT

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Abstract: *Agriculture is the backbone of Indian economy. Almost 70% of farmers still involved directly or indirectly in traditional ways of doing agriculture. In the current scenario agriculture-based plant diseases are of the significant concern as they reduce the productivity and quality of the harvest. Apart from pathogens, climatic conditions also induce various plant related diseases. The observation of plant leaf diseases requires close observation. Awareness of human eye is not so much tougher so as to observe minute variations in the infected part of leaf. Image processing techniques are employed to enhance the quality of images and its texture features. Banana is regarded to be one of the most beneficial plants. Banana leaf is highly prone to diseases like Black Sigatoka, Yellow Sigatoka, Bunchy top virus. This approach will enhance productivity of crops. This project decides about the nature of the leaves. It utilizes the sensor gadgets to recognize the parameters like temperature, moistness and shade of the leaves. Hence, it is mandatory to monitor the environmental parameters of the agriculture field which is done using RFC (Random Forest Classifier) technique from the GLCM (Gray Level Co-occurrence Matrix) features. The images of the crops will be taken by sensor cameras and these images will be sent to the cloud server via raspberry pi3 model. Plant disease detection required steps are image acquisition, image–preprocessing, image segmentation, feature extraction and classification. This project aims to confirm that RFC-GLCM based classification performs better for hill banana dataset.*

Keywords – Raspberry pi3, Image Acquisition, Segmentation, Feature Extraction.

1. Introduction

Agriculture is the mother of all cultures. The focus is on enhancing production, without considering the environmental impacts that has resulted in environmental poverty. As disease of the plants is inevitable, detecting disease plays a serious role within the field of agriculture. Plant pathogens contains fungi, organism, bacteria, viruses, phytoplasmas, viroid's etc. Three components are absolutely necessary for diseases to occur in any plant system and which can infect all kinds of plant tissues including leaves, shoots, stems, crowns, roots, tuber, fruits, seeds and vascular tissues. Therefore, detection and classification of diseases is a crucial and urgent task.

The eye observation of experts is that the most approach adopted in practice for detection and identification of plant diseases. However, this needs continuous one-to-care of experts

which might be ridiculously affluent in large farms. We will analyse the image of disease leaves by using computer image processing technology and extract the features of disease of disease spot according to colour, texture and other features from a quantitative point of view. Due to which consulting experts even cost high also as time consuming too. In such condition the optional technique proves to be helpful in monitoring large fields of crops and automatic detection of diseases by just seeing the signs on the plant leaves make it easier also as cheaper. This also supports machine vision to provide image based automatic process control, inspection, and robot guidance disease identification by visual way is more laborious task and at an equivalent time less accurate and may be done only in limited areas. Whereas if automatic detection technique is used it'll take less efforts, less time and more accurately. plants have some general diseases like brown and yellow spots, or early and late4 scorch, and other viral, fungal and bacterial diseases. Image processing is that the technique which is employed for measuring affected area of disease, and to work out the difference within the colour of the affected area.

Banana is one of the most food cum fruit crops that have capability to provide abundant income to the farmers and country's economy. But this capability of banana crop isn't fully enjoyed by the farmers as there are various threats that decrease the assembly. Major threat in banana production is caused by pests and diseases that reduce crop productivity leading to heavy loss for farmers. Diagnosis and identification of plant diseases accurately in early stage facilitate farmers to possess a much better control over the disease severity.

Symptoms of those pests and diseases are varied. In some crops diseases are visible in early stage and in some crops, they go to be visible only in later stage as there will be no possibility to rescue the crop. Persistent monitoring over the plant helps to spot the pest and disease in early stage and also sustains the plant quality with minimized yield loss. Many farmers aren't aware of the disease identification supported the symptom expression on plants. Hence the support of diagnostic services provided by sources like agricultural research institutions and state farm advisory services are becoming mandatory for banana cultivators. This always involves longer consumption and need additional cost towards advisory services.

Development of an automatic system is that the need for farmers to avoid these inconveniences and to possess a user-friendly suggestion. Automation using innovative computer skills like machine vision, computer vision and image processing provide viable support to the farmers. In agriculture sector, computer vision and machine vision systems are developed for various applications like grading of fruits, vegetables, sorting of fruits, vegetables and detection of weeds. Automatic disease identification and classification is additionally an inevitable area that necessitates the event of automated computer vision or machine vision system with the use of image processing technique.

In the past decades, different combination of image acquisition methods, image enhancement methods, image segmentation methods and have extraction methods are attempted for disease identification and classification. This Paper summarises possible diseases that spot the leaves of banana crop and entirely reviews different image processing techniques that are used for identification and sorting of leaf diseases in banana crop.

Some disadvantages of the Existing system include:

- Perception of human eye gives poor accuracy and which will vary from person to person.
- It's a time-consuming process which requires days of observations and monitoring.
- Expensive in large agricultural fields

2. Banana Leaf Diseases

Banana crop face various bugs start from its initial stage. Most of the symptoms are stated on leaf, stem, flowers, fruits, roots and marks. Major banana diseases that express the indications on leaves are panama disease, moko disease, sigatoka disease, black spot, banana bunchy top, infectious chlorosis, banana streak virus and banana bract mosaic virus disease. These leaf diseases are conferred in detail in the subsequent section.

1) Panama and Moko Disease

Panama disease is produced by a fungi Fusarium oxysporum f.sp.cubense. Symptoms are yellowing of the leaves lower most portions ranging from margin to midrib of the leaves. Yellowing region extends upward leaving heart portion of the leaf alone in green. It is also noted that the leaves have crashes near the base and hangs down in the region of pseudo stem as in Fig. 1(a). Infected rhizomes are the core cause for spread of disease. disease is caused by a bacterium solanacearum. Symptoms are yellowing of leaves in upward direction. Petiole of the leaves break origins the leaves to hang down as in Fig. 1(b).

Figure 1. (a) Panama disease, (b) Moko disease

2) Sigatoka and black spot diseases

Sigatoka disease is instigated by the fungus Mycosphaerella gloeosporioides. Signs are small light yellow or brownish green narrow streaks on leaves and it spreads over the whole leaf as in Fig. 2(a). Black or brown spots are usually found in the pretentious leaves. Leaves dry speedily and cause to defoliate. Black spot disease is instigated by the fungus Phyllostictina musarum. It causes dark black or brown spot in the middle of leaves as in Fig. 2(b).

Figure 2. (a) Sigatoka disease, (b) Blackspot disease

3) Bunchy top virus, infectious chlorosis and streak virus

Banana bunchy top disease is instigated by the banana bunchy top virus. Main symptoms are size of the leaves is reduced and they become delicate and feeble as in Fig. 3(a). Infectious chlorosis is caused by the banana cucumber mosaic virus. Spread of disease is caused by the infected marks and aphid vectors. Symptoms are appearance of curls, twists in leaves and new leaves are in vertical upright position as in Fig. 3(b). Banana streak virus is a common viral disease in banana leaves by having vertical strips in the leaves and stopovers the growth of the plant as in Fig. 3(c).

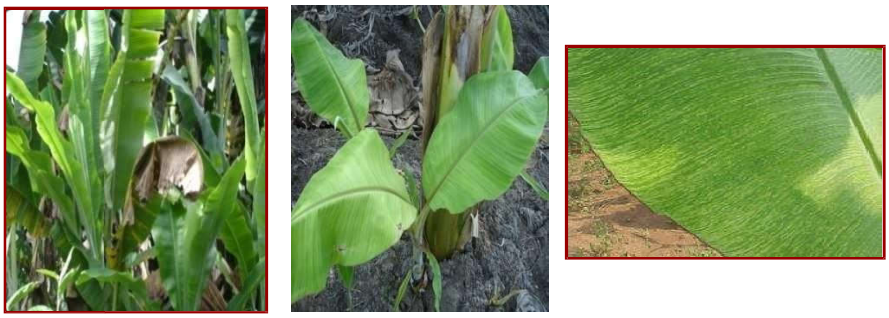

Figure 3. (a) Bunchy top virus, (b) Infectious chlorosis, (c) Streak virus

3. Proposed System

In the proposed system, Automatic detection of plant diseases is made possible through Image processing and IoT. This has made plant disease identification much precise in terms of time. Through image processing techniques, disease affected area can be visually notified in the leaves and stem part of the plant, where the images of the plant leaves are processed and analysed. The images of the plants are captured periodically using camera sensors that are interfaced with the Raspberry Pi3 hardware model.

From the acquired images, requisite GLCM features are extracted. For efficient extraction of features the acquired images must be segmented efficiently which is carried out using k-means clustering segmentation technique. It utilizes the sensor gadgets to recognize the parameters like temperature, moistness and shade of the leaves. Apart from pathogens, climatic changes in the field also cause diseases which can be measured by sensors deployed in the field i.e.; soil moisture sensor measure the moisture of the soil. The GPS module is used to detect the location of the diseased leaf by the raspberry pi-camera. A humidity sensor senses, measures both moisture and air temperature. Camera is used to capture the images of the leaves. PH sensor works like a voltmeter. The dataset used in this project is the images of hill banana plant. The Architecture of the proposed system is shown in below consisting of the visualization of Raspberry pi interfacing with sensors.

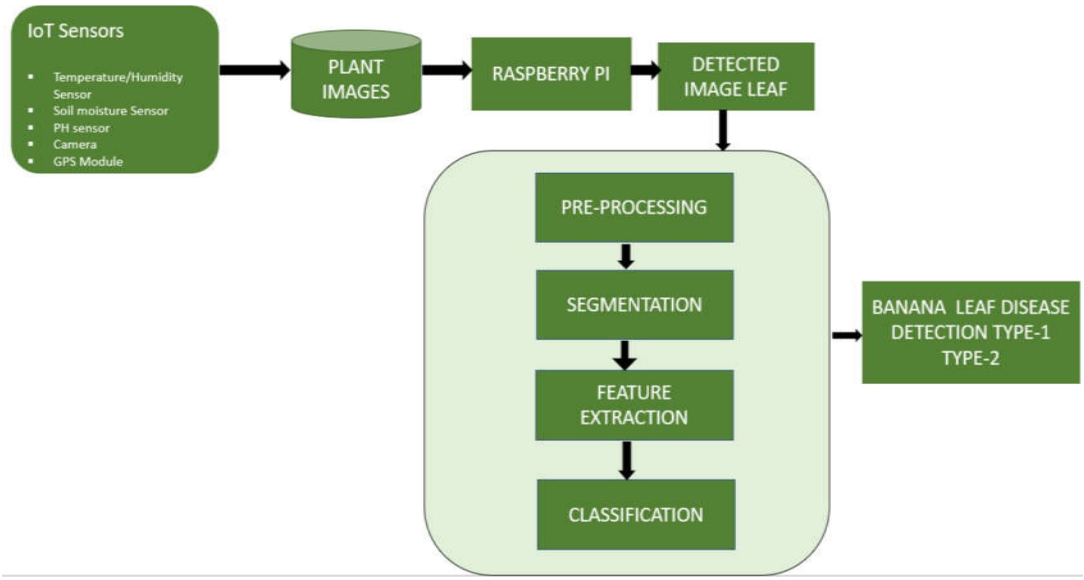

Figure 4. Architecture of the Proposed System

The Proposed system is divided into five modules that are classified as:

- Image Acquisition using IoT
- Image Pre-processing
- Image Segmentation
- Feature Extraction
- Classification Technique

1. Image Acquisition using IoT

In this acquisition phase the images of the plants are captured periodically using camera sensor that is interfaced with the Raspberry Pi3 hardware model. Once the images are captured it is pre-processed.

2. Image Pre-processing

The acquired images undergo pre-processing so that the contrast of the image is enhanced for better segmentation, which will help in appropriate classification. First the acquired image is resized to 256*256. Then, the resized color (RGB) image is converted to gray image by using RGB to gray conversion technique. Then the histogram is equalized using histogram equalization technique in order to enhance the contrast of the image. Through this technique the intensities would be distributed better.

The advantage of this technique is that it's an easy technique and an invertible operator. Histogram is a discrete function that is defined as in Eq. (1),

$$H(r = k) = nk. \quad (1)$$

Normalization of histogram can be done using Eq. (2)

$$P(r = k) = nk/n \quad (2)$$

where,

$P(r = k)$ = normalized histogram function.

nk = number of pixels with intensity k.

n = total number of pixels in the image.

3. Image Segmentation

In this phase, the histogram equalized image is segmented by k-means clustering segmentation technique. The aim of segmentation is to represent an image in better manner for easy analysis. Image segmentation locates objects and boundaries in images. A method that divides a set of data into a defined number of groups is clustering. In k-means clustering, it partitions a collection of data into k groups of data analysis. A method that divides a set of data into a defined number of groups is clustering.

Input: Number of clusters, k and dataset

Step 1: Decide number of clusters k and center.

Step 2: For every pixel of an image, the Euclidean distance d is calculated, between the center and pixel of an image using the relation given,

$d = p(x, y) - c_k$

Step 3: Based on distance d, assign all the pixels to the nearest center.

Step 4: After all pixels have been assigned, recalculate new position of the center using the relation given below.

Step 5: Repeat the process until it the tolerance or error value is satisfied.

Step 6: Finally, reshape the cluster pixels into an image.

Output: k- clusters, segmented image.

K-means clustering algorithm.

4. Feature Extraction

From the segmented image texture features are used mainly colour, texture, and shape features have been extracted. The equations to calculate the features from the GLCM matrix. The Gray Level Co-occurrence Matrix (GLCM) technique is a method for extracting second order statistical texture features.

A GLCM is a matrix where the number of gray levels is equal to the number of rows and colums in the image. The matrix element P (i, j |dx, dy) is the relative frequency with which two pixels of an image that is separated by a pixel distance (dx, dy), occur within a given neighborhood with each having intensities i and j.

5. Classification Technique

After repossessing the features at the monitoring site Random Forest Classification (RFC) technique is employed. Random forest algorithm is a class of supervised classification algorithm. It creates the forest with defined number of trees. The forest is more robust when there is more number of trees.

The forest with maximum number of trees provides better accuracy results. It is based on decision tree concept. Since it is a supervised classification it has some set of rules. The prediction on the test dataset has been done following the same set of rules. The pseudocode for random forest algorithm consists of two stages that includes,

1) Pseudocode to create Random Forest

2) Pseudocode to perform estimate from the formed random forest classifier.

Advantages of the Proposed System:

- It will be easy to go for the severity measurement of disease.
- High precision and accuracy.
- Consumes less time.
- Detection of images been classified without any noise.

4. System Design

4.1. Components used

The hardware components used in the system are different sensors namely, Raspberry pi3(model B+),Soil Moisture Sensor, PH Sensor, GPS Module, Camera, Temperature/Humidity Sensor.

1) Raspberry pi

Raspberry Pi is a low-cost, credit card sized computer monitor(or) Tv, and uses a standard keyboard and mouse. Raspberry pi is like a mini computer which consists of Ethernet port, USB slots, input output pins, WIFI port, HDMI port, SD card reader and much more capability. The Raspberry pi has a Broadcom BCM2835, System on a chip (SoC), which includes an ARM1176JZFS 700 MHz processor, Video core IV GPU, and was distributed with 256 megabytes of RAM, later advanced to 512 MB.

Figure 5. Raspberry pi

2) Soil Moisture Sensor

Soil Moisture sensor calculate the water content in soil using capacitance. This device gives the analog additionally digital output. It works on principle of electrical circuit, that is if, soil is wet then current is pass from one terminal to a different terminal, and circuit completes, therefore it shows low price of voltage. The soil moisture id pt coated for high potency, it's anti-rust and device includes a long-life. Soil moisture sensor is connected to raspberry pi using connectors and using python programming. When input and output are in access, output is high or low is shown on terminal, output is send to the server and this result are stored in the information file. Soil moisture levels affect air content, salinity, and the presence of poisonous materials.

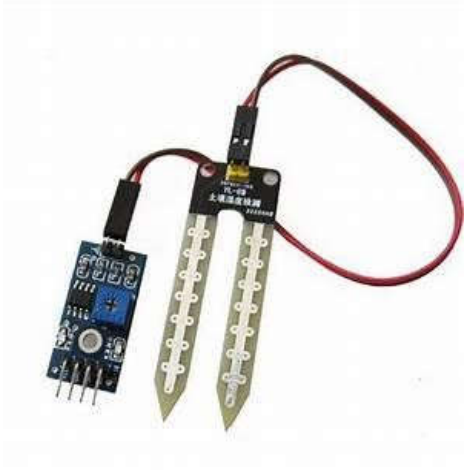

Figure 6. Soil Moisture Sensor

3) Temperature/Humidity Sensor(DHT11)

DHT11 sensor is employed to measure Temperature and humidity both. This is low-slung cost sensor; it shows digital output on terminal of temperature and humidity. DHT11 operates in the voltage range of 3-5v. It shows good results when humidity is between 20-80% with 5% accuracy and 0-50°C temperature with ±2°C accuracy. Results can be get after 2 seconds. DHT11 is connected to the Raspberry PI using connectors.

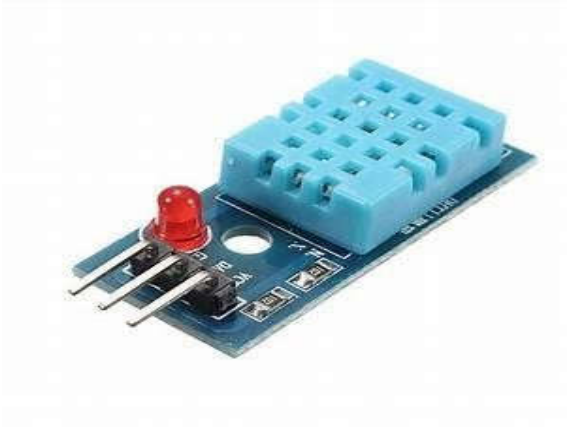

Figure 7. DHT11 Sensor

4) PH Sensor

A pH sensor is a very important parameter to be measured and controlled with in the soil. The PH level of the soil indicates the acidic or basic (alkaline) level in it. The PH worth parameters can facilitate to observe the soil condition at any given point of time.

Ph Sensor Cable Water resistant and rated to 80˚ C. It shall be used for connecting the sensor to pH transmitter whose specifications are provided below. It shall ¾ "NPT female connector at top so that it can be connected with flow through assembly and A rough schematic of flow through assembly is attached herewith.

$$PH= -\log[H+]$$

Figure 8. PH Sensor

5) Pi Camera

The Pi camera module is a transportable light weight camera that supports Raspberry Pi. It links with Pi using the MIPI camera serial interface protocol. It is normally used in image processing, machine learning or in surveillance projects.

The Raspberry Pi Camera Board plugs directly into the CSI connector on the Raspberry Pi. It's able to carry a crystal clear 5MP resolution image, or 1080p HD video recording at 30fps! Latest Version 1.3! Custom designed and mass-produced by the Raspberry Pi Foundation in the UK, the Raspberry Pi Camera Board features a 5MP (2592?1944 pixels) Omni vision 5647 sensor in a fixed focus module.

Figure 9. Pi Camera

6) GPS Module

GPS receivers use a collection of satellites and ground stations to calculate position and time just about anywhere on earth. With this data and some math, a ground-based receiver or GPS module can calculate its position and time.

Figure 10. GPS Module

5. Implementation

Plant disease detection system includes interfacing with sensors with raspberry pi. The parameters of measuring the disease are Temperature/Humidity sensor, Soil moisture sensor and PH sensor. All the sensors are connected with proper connections. The proposed IoT enabled disease detection and classification system is implemented using open CV-python environment. Raspberry Pi deployed at the transmitter side act as the base station and Windows 10 PC/ laptop is at the receiver site. First, the images of the plants are captured periodically using camera sensors that are interfaced with raspberry pi hardware model. These captured images are compared with the existing dataset and then will be uploaded to the raspberry pi. If the leaves are detected to be diseased, then it will further does the Image processing techniques and are used to determine the texture features. After that it will classify the which type of disease the banana leaf has.

For implementation, nearly 200 images of the hill banana plant are used. Two diseases specifically named bunchy top of banana and sigatoka leaf spot disease that majorly affects the cultivation yield are chosen for demonstration and analysis of the system. These two diseases pose a great threat to the cultivation yield due to their easy spreading nature. In the image acquisition part, the plant pictures area unit non-heritable and area unit resized to 256* 256 within the image pre-processing part. The resized image is reborn to grey image. Then the bar graph of the resized grey image is equalised by bar graph equalisation technique so the intensities of the image will be distributed higher. This system enhances the distinction of the image to extract the affected components of the images. Segmentation of the bar graph equalised image is finished by k-means clustering algorithm. Then the GLCM options that area unit extracted from the divided image area unit uploaded to the cloud.

Figure 11. Experimental setup for sensor implementation.

6. Results

Hill banana plant detected as bunchy top of virus and sigatoka diseases. Below figure shows the displayed results.

(a) (b) (c)

Figure 12. Hill banana plant detected as bunchy top of banana disease. (a) Query image. (b) Pre-processed image. (c) Segmented image.

Figure 13. Hill banana leaves detected as sigatoka leafspot disease. (a) Query image. (b) Pre-processed image. (c) Segmented image.

7. Conclusion

One of the vital tasks that have to be carried out in the agriculture field is plant disease detection. Diseases are to be noticed at an early stage to evade the spread of the diseases to other plants. Sorting of diseases is equally important in order to apply the solutions and treat the diseases as soon as they are sorted. The proposed system spots the plant diseases earlier utilizing image processing techniques and IoT. This system enables early detection of diseases in hill banana and remote monitoring of the hill banana field. This reduces the time consumption and cost.

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