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A Review on Plant Disease Detection Using Image Processing

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***Abstract*— India is the agriculture based country, since it contributes 7.68 percent of total global agricultural output. In India, agricultural sector contributes about seventeen percentage of total Indian gross domestic product (GDP). Effective growth and improved yield of plants are necessary for increment of farmer's profit and economy of India. For this purpose farmers need domain experts for manual monitoring of plants. But manual monitoring will not give satisfactory result all the time. Moreover, domain experts are not available at all regions and are expensive as farmers have to pay fees including travelling charges. Hence, it requires developing an efficient smart farming technique which will help for better yield and growth with less human efforts. In this paper, we provide a review on methods developed by various researchers for detection of diseases in plants, in the field of image processing. It includes research in disease detection of plants such as apple, grapes, pepper, pomegranate, tomato etc.**

Keywords*— Classification; Feature extraction; Image processing; Plant disease; Symptom

I. INTRODUCTION

The diseases in plants can be determined by observing specific patterns in plants, but it is difficult to obtain these patterns in order to maintain plant's health. There are various techniques available such as spectroscopic and imaging technology which can be used to obtain patterns. Farmers can make use of automation techniques and tools to integrate knowledge, product and services to improve productivity, grade and yield with the help of smart farming. It helps farmers to identify the plant disease in primary stage and take time to time decisions which in turn saves time and reduces loss of plant due to diseases. Farmers will also be able to identify different grades of fruit before marketing.

The purpose of this paper is to survey on how to monitor diseases on plants and suggest better solution for healthy yield and productivity. Many existing systems use two databases of images, one for query images and other for training images. Diseases of three fruits namely apple, grapes and pomegranate have been identified by many systems. Few types of fruit plants such as apple, grapes and pomegranate and their respective diseases are discussed below.

A. Apple Diseases

The apple fruit is one of the most popular fruits worldwide. It has many health benefits and comes in a variety of colors and flavors. This plant suffers from some common diseases such as

1) Apple Scab: It causes most devastating apple infection. It occurs throughout the apple-growing areas. During the bloom in cool and wet weather, apple scab is more severe but it is not reasonably significant in dry or warm climates. Signs of apple scab are visible on leaves, petals, flowers, husk, fruit, young shoots and bud scales of apple tree. Mostly infection on the fruit and leaves are common and obvious. Fig. 1 shows apple scab disease on fruit.

Fig. 1. Apple scab disease

2) Apple Rot: It is a fungus caused due to Botryosphaeria obtusa. It attacks on fruits, leaves and bark of apple plant. The first symptom of apple rot appears on outer surfaces of leaves one to three weeks after petiole fall as small, purple blotch after which centre turn brown tan and yellowish brown as shown in Fig. 2. Second stage of apple rot occurs after few weeks. In this stage secondary enlargement of leaf spots occur. Leaf that is highly infected drops from the tree.

Fig. 2. Apple rot disease

3) Marssonina Leaf Blotch: This disease is identified by the formation of dark green circular blotches over the leaf. It turns into brown leaf spots which eventually become dark brown over a period of time. When leaf is badly affected by this disease large dark brown patches are formed and color of leaf turns into yellow as shown in Fig. 3. This disease occurs because of high rainfall and moderate temperature during the formation of fruit in apple tree.

Fig. 3. Marssonina leaf blotch disease

4) Black rot canker: This disease appears first on leaves in the beginning of spring season. Purple color dots appear on leaves which will form circular damaged region on leaves. The boundary of damaged region remains purple, but centre turns into brown as shown in Fig. 4. After some days these spots will enlarge in size and form circular bands with same centre on fruit. Color of these bands varies from brown to black.

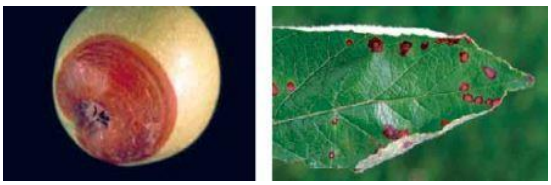

Fig. 4. Black rot canker disease

5) Apple mosaic: Apple mosaic disease appears in the form of cream color patches on leaves as shown in Fig. 5. During hot summer these patches might become destructive, and leads to distortion of leaves and reduction in size of leaves. Apple stem grooving virus forms symptoms such as swelling of the stem, chlorotic leaf spots, stern grooving and pitting.

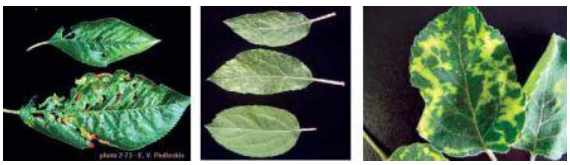

Fig. 5. Apple mosaic disease

B. Grape Diseases

Grapes are a type of fruit which grow in clusters and comes in various colors such as green, black, dark blue, yellow and crimson. During growth, this plant suffers from bacterial and fungal diseases which are listed below.

1) Black Rot: Black rot is most widely occurring and severe disease. In this disease, fungus attacks canes, tendrils, leaves and fruit and it is most devastating in hot and moist areas. First sign of black rot is visible on leaves as black border forms around the edge and small yellowish spot is formed, after that spot enlarges. Mostly symptoms appear after half growth of grapes. Fig. 6 shows black rot disease in grapes.

Fig. 6. Black rot disease in grapes

2) Powdery Mildew: It is originated by fungus uncinula necator, it is also called as Oidium. Only grapes and other few related species are affected by this fungus. It is most frequently occurring disease on grapes. Primary symptom of powdery mildew is whitish or greenish powdery patches appearing on the underneath of basal leaves. It also causes leaf curling, withering along with blotched or deformation of badly infected leaves. Fig. 7 shows powdery mildew disease.

Fig. 7. Powdery mildew disease

3) Downy mildew: This is the fungal disease of grapes. It occurs on leaves and can result in crop loss. Yellow color patches will be formed across the veins of leaves. Within few days, back side of the leaves will be covered by white cotton like mildew as shown in Fig. 8. This disease usually occurs in spring season because of cool, moist and cloudy weather.

Fig. 8. Downy mildew disease

4) Anthracnose: This disease is also called as bird's eye rot since spots on fruit look like eyes of the bird. Initially, red spots will be formed on the berry. Within few days these spots will become disk shaped, depressed and turn into gray color. Further, spots will be surrounded by a dark boundary, because of which it looks like eyes of the bird as shown in Fig. 9. Continuous or irregular rainfall and high humidity cause this disease.

Fig. 9. Anthracnose disease in grapes

5) Bacterial Leaf Spot: This disease affects shoots, berries and leaves. The small water dipped spots are formed on bottom of the leaves across veins as shown in Fig. 10. In few days these spots form large blotches. Brown black color damaged regions are formed on the berry, which will become tiny and shrivelled.

Fig. 10. Bacterial leaf spot disease

6) Rust: The symptoms of this disease appear as innumerable spots with orange color on the back side of the leaves as shown in Fig.11. In serious cases these spots which are rounded swelling are formed on the whole surface of leaves resulting into loss of leaves.

Fig. 11. Rust disease on leaves of grapes

C. Pomegranate Diseases

The pomegranate is a small fruit tree that grows between 5 meter and 8 meter tall. This is used in cooking, baking, juice blends and alcoholic beverages such as cocktails and wine. This plant suffers from few diseases during its growth such as

1) Bacterial Blight: This disease was first recorded in Delhi (India) in the year 1952. Until 1998 bacterial blight was considered as a lower economic threat. However, now a day this disease occurs widely and has been recorded in all states. This disease occurs in all pomegranate growing states like Maharashtra, Karnataka, and Andhra Pradesh. Preliminary symptoms for the disease can be black color spots surrounded by bacterial slime. 90% yield of pomegranate depletes due to bacterial blight. Fruits crack due to this disease as shown in Fig. 12.

Fig. 12. Bacterial blight disease

2) Aspergillus Fruit Rot: This disease appears when flower begins to open after the rainfall and it infect the internal portion of pomegranate. Tiny off color in the skin and less weight due to internal decay are some of the exterior signs of disease. But this problem usually is not apparent until harvesting or during fruit sorting. Without any external symptoms fungus may grow within the fruit. Mostly infected fruit show some yellowish to brownish red discoloration and are slightly off-color such as a pale red as shown in Fig. 13.

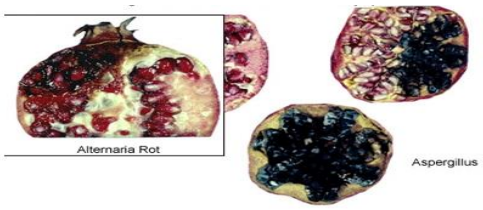

Fig. 13. Aspergillus fruit rot disease

3) Anthracnose: This disease first appears in the form of black spots on leaves and then color of leaves changes to yellow and defoliation occurs. It also appears on tender or mature fruits as brown spots which are circular in the beginning and later become irregular shaped spots. These spots spread on part of fruit or on whole fruit as shown in Fig. 14. This disease occurs usually in the month of August or September due to high humidity.

Fig. 14. Anthracnose disease on pomegranate

4) Cercospora fruit spot: This is a disease which occurs on pomegranate fruit in the form of pale brown spots as shown in Fig. 15. It also appears on twigs as black color spots. The affected regions on the twig will be depressed and flattened, surrounded by raised boundary. The twigs which are affected by this disease will dry up and in some serious cases, entire plant of pomegranate dies.

Fig. 15. Cercospora fruit spot disease

5) Cercospora leaf spot: This disease occurs on leaves in the form of small brown color spots surrounded by yellow color circle. These circular spots spread over the leaf area and turn into brown color with time as shown in fig. 16. On lower surface of the leaves grey color structure is formed due to group of sunken spots.

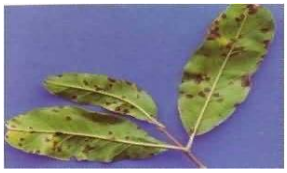

Fig. 16. Cercospora leaf spot disease

This paper gives the overview of the technical implementations in the field of plant disease detection using image processing. First section gives the introduction about diseases of fruit plants such as apple, grapes and pomegranate. Second section describes related work carried out in past ten years for detection of diseases in plants using image processing techniques by various researchers. In third section, we discuss challenges in plant disease detection. Fourth section explains system architecture which is commonly used to detect plant diseases and last section gives the conclusion.

II. Related Work

Number of attempts has been made to bring smart farming together to work on plant disease detection. In 2017, Zang et al. [1] have proposed a correlation based feature selection method to identify apple leaf disease. Color, texture and shape features are used as input for support vector machine (SVM) to classify apple leaf diseases such as mosaic, powdery mildew and rust. However, it fails to identify apple leaf disease under natural illumination. In 2016, Francis et al. [2] have proposed a method to identify leaf diseases in pepper plants. It identifies two types of diseases, quick wilt and berry spot disease with the help of neural networks. Matlab R2012A is used for image analysis. In 2015, Bhange and Hingoliwala [3] suggested a solution for the recognition of pomegranate fruit disease. In this process, web based technique is applied to help farmers in recognizing fruit diseases. Farmers could capture an image of fruit affected by disease and upload it to the system. After this farmers would be able to see if the fruit is affected by bacterial blight or not. Awate et al. [4] proposed a system to supervise the diseases on fruits like pomegranate, apple and grapes and suggest alternate solution for healthy yield and good productivity. However it fails to estimate the severity of the disease automatically.

In 2014, Deshpande et al. [5] have proposed the automatic system which is used for grading pomegranate leaf diseases. They have worked on most common disease in pomegranate that is bacterial blight. For segmentation they have used K-Means clustering algorithm. This system is not useful for farmers directly but plant pathologists can make use of this system. Rupanagudi et al. [6] proposed a method to estimate maturity in tomato. This method is cost effective and is able to classify different stages in ripening of tomato using features such as color and texture. This method is used only to examine the ripeness of tomato but not to identify the disease of tomato. Ghaiwat and Arora [7] have done survey on identification and classification of diseases in leaf. This work presents a survey on different classification methods. Existing systems have used various classification techniques like k-nearest neighbor classifier, artificial neural network, probabilistic neural network, support vector machine, genetic algorithm, principal component analysis and Fuzzy logic. Classification of leaf diseases has several applications in the field of agricultural research. In 2013, Jhuria et al. [8] indicated a method using image processing to identify fruit diseases and also for fruit grading. The main aim of their work is to examine disease spread on leaves or fruits and give various solutions. They have worked on apple and grape diseases. Features such as texture, color and morphology are used as input for artificial neural network for classification of plant diseases. Tiger and Verma [9] presented an apple recognition technique. Two classes such as normal apple and infected apple have been used. Proposed method uses two layer feed forward network for classification. Dubey et al. [10] proposed a method for fruit segmentation using color features. Unsupervised K means clustering algorithm is used. Apple fruit is used for case study. However, it fails to determine number of clusters required for segmentation of the defects.

In 2012, Naganur and sannakki [11] presented the sorting and grading of fruits using image processing techniques. Fuzzy logic approach is used for classification and grading. Dubey and Jalal [12] have proposed disease identification method for fruits. The method identifies apple diseases such as apple scab, apple rot and apple blotch. Image segmentation is done using K-means clustering technique. Features such as Color Coherence Vector (CCV), color histogram, local binary patterns and complete local binary patterns are extracted. Identification and classification of disease is done using multiclass support vector machine. However, this method, fails to make fusion of more than one type of features. Pertot et al. [13] have provided multilingual web based tool for visual plant disease detection. This system has two users; one who is able to use it for detecting plant disease and another is admin. This system is used for strawberry disease detection. In 2011, Patel and Joshi [14] gave improved solution for locating the fruits on the plant based on multiple features. Multiple feature extraction technique can include steps like extraction of color and intensity feature, extraction of orientation feature, extraction of edge feature, extraction of area from feature maps. The process is entirely automatic and it can work without user involvement. To improve performance it considers numerous features. Al-Hiary et al. [15] suggested an improved solution for automated diagnosis and grading of plant leaves. Disorder can be diagnosed with help of K means

clustering procedure. Barrios et al. [16] provides a solution through which we can achieve fast and accurate testing in laboratories for tomato grading instead of manual testing. Grade assessment of tomato is prime task which can be acquired using image processing. Reis et al. [17] have proposed system for identifying white color grapes for robotic harvesting system. The system was targeted to detect white grapes, during night. However, it is unable to bring the information about the grape maturation. They also have proposed a system [18] to identify bunches of grapes. It identifies and locates bunches of grapes and also classify as white and red grapes. Limitation of this system is that detection of bunches of grapes is done only during night conditions. Sannakki et al. [19] proposed a system to grade the disease on plant leaf automatically. It inculcates information and communication technology in farming. It uses fuzzy logic for grading the disease spread on plant leaf. However, it is unable to provide disease prevention information to the farmers.

In 2010, Sankaran et al. [20] suggested imaging, spectroscopic and molecular techniques. The imaging and spectroscopic technologies are used in agricultural vehicle for detection of plant diseases. Arivazhagan et al. [21] proposed an efficient method for fusion of features such as color and texture to identify fruit. Classification method such as minimum distance classifier is used for identifying fruit. Sandoval et al. [22] have proposed a classification system using machine vision to classify coffee fruits (cherries) depending on level of ripeness. Several classes are considered for different stages of ripening process of coffee fruit. Bashish et al. [23] proposed a method for detection of plant or stem diseases. Segmentation is done using K-means algorithm. Segmented images are used as input to the neural network. However, this method is unable to give prevention information. In 2009, Effendi et al. [24] presented that the quality of fruit is judged by the color, size and type of defects. In this work image identification method is developed to find the maturity level of Jatropha curcas fruit. A back propagation diagnosis model (BPDM) is used for recognizing the image of the matured fruit. Hannan et al. [25] proposed a method for fruit detection. Orange fruit is considered for case study. The enhancement is done using the red chromaticity coefficient. To improve the efficiency of fruit identification, they have used fuzzy logic along with laplacian pyramid transform (LPT). Fernandez et al. [26] proposed a computer vision system to grade the grapes in wine cellars. It provides automatic classification of grapes in cooperative wine cellars. It also sorts grapes for the production of different quality wines. However, it is unable to test different variety of grapes. Syahrir et al. [27] proposed image processing method for estimating tomato maturity. It judges the maturity and expiry date of tomato based on their color. Red and green values are extracted during feature extraction. These values are used for identifying the maturity percentage of tomato and expiry date. It fails to separate tomato from other fruits or vegetables. Yin et al. [28] proposed a method of ripe tomato extraction using features such as color and morphology. There are some drawbacks of this method such as it results in the false cluster segmentation for ripe tomato.

In 2008, Meunkaewjinda et al. [29] proposed a system using multiple artificial intelligent techniques for automatic diagnosis of plant disease. It can diagnose disease spread on plant leaf without need of any expert once the system is trained. Work is done on grapes. SVM classifier is used to classify the grape leaves into scab or rust disease or no disease. In 2007, Zhang et al. [30] proposed a method to identify disease in cotton leaf. Fuzzy curves and surfaces are used to select features. Fuzzy curves are used to separate a small set of notable features from the set of actual features. No proper treatment advisory can be given by this approach automatically to prevent further loss.

The system architecture for fruit disease detection using image processing includes various phases as shown in Fig. 17. The various phases for fruit disease detection are discussed in the following section.

III. SYSTEM ARCHITECTURE

The common system architecture for plant disease detection using image processing is as shown in Fig. 17. The various phases for plant disease detection are

A. Image Acquisition

It is the process of pictorial image creation of a physical view or the internal structure of an object. Image acquisition can be widely described as the activity of restoring a picture from some origin, usually a hardware-based source which can be processed along with processes that need to appear afterwards. Image acquisition is consistently the initial condition for the work flow series of image processing because as processing is possible only with the help of an image. The image obtained is entirely natural and is the consequence of any hardware which was handled to produce it.

B. Pre processing

Pre processing involves enhancement of the visual appearance of images, increasing or decreasing the number of pixels of the dataset, resizing images and removing noise from the images.

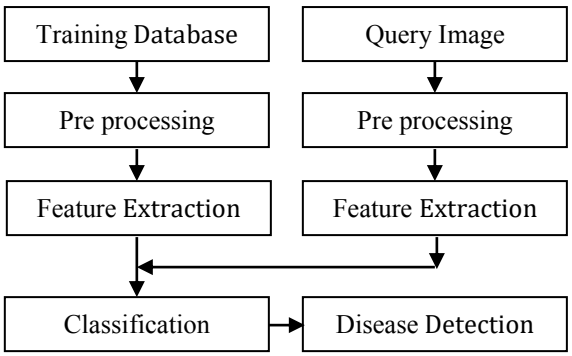

Fig. 17. System architecture

C. Image Segmentation

It is the method of dividing a digital image into several parts. The primary aim of segmentation is to recognize objects

or extract the related information from images, so that analyzing an image becomes easier. Objects and bounding line of images are located by using image segmentation. Pixels with similar label portion share distinguishing features for allocating a label to each pixel in an image.

D. Feature Extraction

Feature extraction is the process of deriving a set of values called features from an image, which provides information about the image for further processing. In the process of identifying the diseases in plants, features such as color, texture, morphological and color coherence vector are commonly used.

1) Color features: A basic feature to observe change in plants is color. Color feature is commonly used by many researchers for classification of plant diseases. There are many methods for color feature extraction such as color histogram, histogram intersection, color correlogram, color co occurrence matrix, color coherence vector etc.

2) Texture features: Texture is nothing but a duplicated structure of information or the arrangement of the structure that occurs at uniform intervals. Since every plant disease has unique structure, texture features are used to detect and classify plant diseases.

3) Morphological features: Morphological features refer to a shape or a particular form of an object. As plants and plant diseases come with various shapes, morphological features are mostly used for plant disease detection. Using these features we can extract various components of an image. These components are used for extracting the boundary which separates different regions in an image and hence, plant disease can be identified easily.

E. Pattern Matching and Classification

It is the procedure of examining stated successions of tokens for the existence of the elements of some pattern. The task of matching algorithm is to compare features with index features of the image present in the database. Classification is a process of identifying the category of the observed pattern. Two major categories of classification are supervised and unsupervised. In supervised classification, training is required where user can choose sample pixels to form a class. Unsupervised classification needs no training and results are based on the software analysis without sample classes. Classification techniques such as support vector machine, neural networks, k- nearest neighbour, fuzzy logic etc. are used for plant disease detection.

IV. CHALLENGES

There are few challenges [31] in plant disease detection using image processing techniques which are listed below

A. Collection of data set

Basic need of image processing is creating a database of images. To acquire images of plant diseases, one has to travel to different places. Data collection will be a challenging since variety of plant diseases may not be available at some farms and diseases occur only during some seasons.

B. Image background

Image segmentation is important phase of image processing, where we separate most required part of image. Leaf image segmentation may be a challenge if background contains plants, leaves and some other green elements.

C. Image capture condition

Automatic plant disease detection systems give steady and efficient results, only if all the images are captured under same condition. Capturing images under same condition is possible only inside laboratories. It's a challenge to capture images under same condition in the field because of uncontrollable environment.

D. Symptom segmentation

Most plant disease symptoms have no well defined edges and they fade on plants slowly because of which there will not be a proper segmentation, which will affect final result.

E. Symptom variations

Symptom depends on environment, disease and plant. Any change in these elements may result in symptom variations. It's a challenge to identify the plant disease with symptom variations.

F. Multiple simultaneous disorders

Many times automatic plant disease detection systems may wrongly assume that there is only one disorder present in an image. Pests and nutritional deficiencies may occur simultaneously because there is maximum possibility of plant being attacked by other disorders after having infected by some disease.

G. Different disorders with similar symptoms

Many plant disorders have similar symptoms such as diseases, nutritional deficiencies, pests, phytotoxicity, excessive cold or heat. It's a challenge to differentiate and identify the disorders by automatic plant disease detection techniques.

V. CONCLUSION

In this paper, we present a review of the technical implementations in the research area of plant disease detection using image processing techniques. From literature it is evident that color, texture and morphological features are most suitable to identify and classify the diseases in plants. Most commonly used classification techniques for classifying plant diseases are artificial neural networks (ANN) and support vector machine (SVM). Automatic detection of plant diseases would solve the problem of expensive domain expert. Detection of plant diseases in early stage would help farmers to improve the crop yield, which in turn improves Indian gross domestic product (GDP).

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