FUZZY LOGIC BASED SUGARCANE LEAF DISEASE IDENTIFICATION AND CLASSIFICATION USING K-MEANS CLUSTERING AND NEURAL NETWORK

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Abstract—In Indian agriculture, sugarcane is the most important plant. The sugarcane plant plays a vital role in Indian economy. Sugarcane refers to any of several species of giant grass in the genus Saccharum that have been cultivated in the tropical climates in South Asia and Southeast Asia since ancient times. The second largest country in the production of sugarcane is India. The main by-product of sugarcane plant is sugar and it is an essential food item in our day today life. The world produced about 168 million tonnes of sugar in 2011. The farmers are much interested in cultivating sugarcane plant in their farms to gain more profit. Generally, the sugarcane plant will be affected mainly due to lack of natural efficiencies such as sunlight, water and fertility of soil. The main affected area of the sugarcane plant is its leaves. About 15% of sugarcane leaf is infected by various disease, which reduces the quality and quantity of sugarcane production. This is due to various fungal and bacterial disease caused by viruses. This will leads the farmers to spend more time to identify the disease and the cost will be increased to prevent the disease. This paper aims to identify and classify the affected sugarcane leaf automatically at its early stage itself by using Image Processing techniques and MATLAB tools. Early detection and classification of plant disease is used to control these diseases and reduce the severity of infection. This experiment can predict more accurate result.

Keywords—Leaf image, K-means clustering, Feature extraction, Fuzzy logic, Neural network.

1. INTRODUCTION

Sugarcane is the most important crop in different states in India like Tamilnadu, Andhra Pradesh, Telungana, Uttar Pradesh, and Karnataka. In Indonesian agriculture, many researches are conducted to achieve better precision agriculture of sugarcane plant. Several viral and bacterial diseases occurs in sugarcane plant which affects the stem and leaves of the plant. The various sugarcane leaf disease are categorized as scorch disease, rust disease, red rot disease, ring spot disease, etc.. These diseases will leads to the appearance of spots on the leaves and that leaf will be identified as the diseased leaf. The various disease caused on the sugarcane leaf will predict the quality, cost and yield of productivity. The sugarcane leaf disease can be automatically identified and classified by various image processing techniques such as acquisition, filtering, segmentation and feature extraction. [1]. The diseased spot of the leaves are taken for analysis from a high definition digital camera, smart phones, etc., [2]. The quality of the image is improved by using some pre-processing methods. [3]. The important task to monitor the large fields of crops is to segment and identify the diseased leaf. [4]. The affected leaf is analyzed by image processing techniques and the features are extracted based on color, size, texture, etc., [5]. Finally, the classification of diseased leaf is performed and the corresponding pesticide is suggested for each disease. [6]. This proposed experiment will helps to improve the quality and the productivity will also be increased.

2. RELATED WORKS

Various methods have been proposed by the literature survey which uses many techniques related to this experiment. Research[1]. “Sugarcane leaf disease detection and severity estimation based on segmented spots image”, proposes a system to identify the severity spot disease which on leaves based on segmented spot. Support Vector Machine (SVM) classifier technique is used here. SVM will uses L*a*b color space for color feature extraction and Gray Level Co-Occurrence Matrix (GLCM) for texture feature extraction. This research is capable to identify the spot disease with an accuracy of 80% and 5.73 error severity estimation average. Research[2];“Feature Extraction for Identification of Sugarcane Rust Disease”, proposes a research to find appropriate features that can identify rust disease of sugarcane leaf. It is based on Support Vector Machine (SVM) classifier and features of leaf such as shape, color, size and texture features. This research will produce an accuracy of 96.5%. Research[3]. “Leaf Image Segmentation Based On the Combination of Wavelet Transform and K-Means Clustering”, proposes a model to segment the diseased leaf using K-means clustering algorithm. The result of this proposed model produces better convergence when compared to existing methods of segmentation. Research[4]. “Advances in Image Processing for Detection of Plant Disease”, uses OTSU algorithm. This will identify the green colored pixels and the pixels are masked based on the threshold values. This algorithm will produce the result of precision between 83% and 94%. Research [5]. “Detection of unhealthy region of plant leaves and classification of plant leaf disease using texture features”, is a software solution for automatic detection and classification of plant leaf disease. The classifier used for this model is minimum distance criterion and SVM algorithm. Research[6]. “Application of BP Neural Network to Sugarcane Disease...
Spots Classification”, which uses BP neural network with 3 input neurons, 12 hidden neurons and 1 output neuron. This algorithm will produce more accurate result when compared to fuzzy K near neighbor algorithm. Research[7]. “Identification of Sugarcane Leaf Scorch Disease using K-means Clustering Segmentation and K-NN based Classification”, proposes a model to identify the scorch disease in sugarcane leaf and classify the diseased leaf separately by using some image processing technologies. The technique used in this research is K-means clustering for segmentation and K-neural network for classification of the diseased leaf from the normal leaf. This experiment can produce an accuracy of about 95%. Research [8]. “A Real Time Image Segmentation Approach for Crop Leaf”, proposes a model for pre-processing the image and to segment them based on the requirement. Fuzzy C-means clustering is used for segmentation and morphological operation and blob analysis was proposed. This approach can be used to separate the plant leaf from the complicated background. Research [9]. “Edge Detection in Digital Images Using Fuzzy Logic Technique”, proposes a method to segment the images into regions using floating 3x3 binary matrix. This proposed method will be based on linear Sobel operator to give permanent smoothness and straightness. These literature researches are used for the study of various image processing techniques involved in the proposed system.

3. PROPOSED MODEL

Usually, the farmers uses two methods to detect disease in sugarcane field. First, by seeing some defected symptoms in the sugarcane leaf, farmers used to inform the agriculture officers in the nearby locality and they will identify the disease and cure the disease. Next option, Government of India have provided more numbers of call centre to guide and help the farmers. If the farmer identified any physical changes in the leaf, they may contact the resource person. By following the instruction given by them, the farmers can rectify and control the spreading of disease to nearby plants. These two methods are manual. Based on the literature researches, a new proposed system is investigated. The main objective of this proposed model is to identify and classify the diseased leaf of sugarcane plant at the early stage itself. In this paper, the sugarcane leaf is taken as the input image and the leaf image are taken for the disease detection and classification from the sugarcane field. The input image is captured by using the high definition digital camera and smart phones. The input image is enhanced by using some methods. The noise in the acquired image is removed and the quality of the image can be improved by using various pre-processing techniques. These pre-processing techniques are used to remove the unwanted details, noise, blur from the acquired input image. If necessary the background of the image can also be removed by using these pre-processing methods. K-means clustering algorithm is used for the segmentation part. K-means clustering is an efficient method used for pattern recognition. In K-means clustering, a centroid vectoris computed for every cluster. It is extended to handle the concept of partial truth where the truth value may range between completely true and completely false. Fuzzy logic method is used to detect the affected leaf. It is extended to handle the concept of partial truth where the truth value may range between completely true and completely false. By using fuzzy logic, the disadvantages of the existing techniques and it can provide the accurate result. By identifying the affected leaf, the type of disease affected to the leaf is analyzed. Based on the disease type, the sugarcane leaf is classified. The classification process can be performed by using artificial neural network. The neural network models have been proposed for classification of pattern, function approximation and regression problems. The overall process is described below:

STEP 1: The input image is captured by using the high definition digital camera or by using smart phones.
STEP 2: The captured image is enhanced by using pre-processing techniques.
STEP 3: Segmentation of the diseased leaf is performed.
STEP 4: By using the extracted features, the diseased leaf is identified.
STEP 5: The affected leaf is classified from the normal leaf and the corresponding pesticide is suggested to the disease. The proposed system can be used to identify the diseased leaf at early stage itself. The techniques used here will be explained briefly at the below.

4. GENERAL ARCHITECTURE
The following Fig. 1 shows the overall process involved in this paper.

Fig. 1 Procedure of Proposed Model

**IMAGE ACQUISITION**
In this paper, the diseased leaves are taken for the consideration to identify and classify the disease in the sugarcane leaf. Image acquisition is nothing but getting an input image from any source. Initially, the image of the sugarcane leaf is acquired by using the latest digital camera.
The camera should have a high definition quality. The image can also be captured by using a smartphone camera. After capturing the image by a digital camera or mobile phone, the captured leaf image is transferred to a Personal Computer (PC). Then, the image processing techniques are applied to the input image by using MATLAB R2012a. The acquired leaf image will be of any size. For the further processing, the image properties can be adjusted to a dimensions of 284x480, width of 284 pixels, height of 480 pixels and the bit depth of 24. The acquired image will be in the RGB color format. The RGB color format is not converted into the gray scale since color based process is carried out in further steps. The diseased leaf image will have some defected symptoms in the layer of the leaf. The diseased leaves are selected and those images are captured for further process. The noises present in the image can be removed by pre-processing techniques.

The sample of the input sugarcane leaf image which is affected is represented as follows,

**Fig. 2 Sample input leaf**

**IMAGE PRE-PROCESSING**

Pre-processing the input leaf image is the initial process for processing to eliminate the noise and blur, calibrate the data radiometrically and geometrically. The input image will be in the RGB color format. The difficulty in detecting the diseased spot is the noise present in the image which is caused due to flash in the camera and noisy background. The objective is to correct the distorted and degraded image data to create a more faithful representation of the real image.

**SEGMENTATION**

Segmentation refers to the dividing or partitioning a digital image into different segments i.e., a sets of pixels which is also known as super pixels. Each segmented region is known as cluster. The clusters are represented by an object in an image. Many information about the image can be gained by using several segmentation methods. The segmentation method employed for this process is color based k-means clustering.

**COLOR BASED K-MEANS CLUSTERING SEGMENTATION**

The pre-processed image is given as the input to the k-means clustering algorithm for segmentation process. The process of organizing the object into groups based on its attributes is known as clustering. Therefore, a cluster is a collection of objects which are “similar” between them and are “dissimilar” to the object belonging to other clusters. The grouping of the input image can be done based on metadata or its description. For every cluster, a centroid vector is computed in k-means clustering technique. K-means clustering will segment the object based on the value of k. The value of k is chosen based on the heuristic that green pixels in the image belong to healthy portion of the leaf sample and should be separated out from that of diseased portion. The segmented images are given as follows,

**Fig. 2 Input image**

The segmented image of this input image is given as follows,

**Fig. 3 Segmented image**

K-means clustering can use the following algorithmic codes to segment the leaf image,

\[
\text{idx} = \text{kmeans}(x, k) \\
\text{idx} = \text{kmeans}(x, k, \text{name}, \text{value}) \\
[\text{idx, c}] = \text{kmeans}(-) \\
[\text{idx, c, sumd}] = \text{kmeans}(-) \\
[\text{idx, c, sumd, D}] = \text{kmeans}(-)
\]

This can be used for partitioning the input image. The function represented here kmeans and x & k are the variables. ‘C’ represents the centroid point i.e., center point of the cluster and ‘sumd’ represents the sum of points to centroid pixels where ‘d’ represents the distance between each pixel. Based on the value of ‘k’, the input leaf image is segmented into different clusters.

**FEATURE EXTRACTION**

The input image data is converted into a set of features. The transformation of the input data into a set of features is known as feature extraction. The relevant information can be extracted if the features of the input image is chosen correctly. The features can be extracted by using the
parameters such as standard deviation, mean, entropy and contrast. The mean and standard deviation are the features extracted as the color feature. Entropy is a measure of the image with the amount of information it may be image texture information. The degree of image sharpness and texture of deep grooves can be extracted from the contrast of the image.

**IMAGE IDENTIFICATION**

The process of identification is used to detect the affected or diseased leaf from the normal leaf. Identification can be helps to classify the affected leaf and the normal leaf. In this paper, fuzzy logic based identification technique is used to identify the infected leaf.

**FUZZY LOGIC**

Fuzzy logic is a form of many values logic in which the truth values of variables may be any real number between 0 and 1, considered to be “fuzzy”. By contrast, in Boolean logic, the truth values of variables may only be 0 or 1, often called “crisp” values. Fuzzy logic has been extended to handle the concept of partial truth, where the truth value may range between completely true and completely false. The fuzzy logic process can be described as follows,

1. Fuzzify all input values into fuzzy membership functions.
2. Execute all applicable rules in the rulebase to compute the fuzzy output function.
3. De-fuzzify the fuzzy output function to get “crisp” output values.

**CLASSIFICATION OF DISEASED LEAF**

The diseased leaves are identified by using fuzzy logic and they are classified. The process of separating the normal leaf and the diseased leaf is known as classification. Classification process can be done by pattern recognition. Neural Networking technique can be used to classify the normal leaf and the diseased leaf.

**NEURAL NETWORKING**

A neural network is an information processing paradigm that is inspired by the way biological nervous systems, such as the brain, process information. It is configured for a specific application, such as pattern recognition or data classification through a learning process. The pattern and symptoms of the leaf are analyzed and they are fed as a database in neural network function. In pattern recognition, the neural network algorithm is a method for classifying objects based on closest training in the feature space. The trained database can be helpful to classify the diseased leaf by comparing the input data with the trained database. Thus the affected leaves are separated based on the type of disease and the corresponding pesticide for each disease can suggested to minimize and cure the disease in the leaf of sugarcane plant.

5. **EXPERIMENTAL RESULTS**

The trained features are obtained from the sugarcane leaves. Each and every class is tested differently to differentiate from normal and diseased leaves. The experiments for the proposed approach were conducted on a personal computer with an Intel Core 2 Duo Processor and 2GB RAM configured with Microsoft Windows 7 and MATLAB R2012a software with image processing Toolbox. The results shown in Table 1 were obtained by using the K-NN Classifier. The number in particular cell indicates that correctly classified leaves against all the conditions of the leaves. The overall accuracy using K-NN Classifier is 98%. From the results it is clear that texture analysis can be used for feature extraction and also it is used to observe that normal and scorch spot diseased leaves.

6. **CONCLUSION**

This project presents an efficient method for identifying and classifying the diseased sugarcane leaf at its early stage itself. Firstly, the proposed method used image processing algorithms to extend pixels dynamic range in RGB color space and to get a better image quality. The segmentation of diseased leaf is performed and the diseased leaf is identified by feature extraction method. Then, the classification of leaf is done based on the type of leaf disease. The new model has resulted high accuracy in identifying sugarcane leaf disease with low error measurement. This experimental results shows that the proposed project is effective and fast to identify and classify the leaf disease.

7. **FUTURE SCOPE**

For the future research, this work can be extended as a development of mobile apps. The work can also be extended for the development of hybrid algorithms such as other clustering methods and Neural Networks in order to improve the recognition rate of the final classification process and further it is needed to compute amount of disease present on the sugarcane leaf. Like some apps in our mobile phones, this model can be created as an app. This can be helpful for the farmers to identify the leaf disease quickly. The farmers can use a smart mobile phones for this process. If the farmers notify any diseased symptoms on the sugarcane leaf, then they will capture the leaf image by using the mobile phone camera. The image is fed as an input to the developed disease detection app. Then the app will segment the diseased part and it will identify weather the leaf is originally affected or not from the extracted feature from the leaf by using some image processing techniques. Then the diseased leaf will be separated from the normal leaf and the pesticide will be suggested to the farmer immediately. This can be helpful to identify and cure the leaf disease of sugarcane plant at the early stage itself.

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