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Review Article

Image Processing for the Identification of Leaf Disease

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I N F O

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A B S T R A C T

This paper explores the application of image processing techniques for the detection and classification of plant leaf diseases, which is crucial for maintaining agricultural productivity. The study focuses on corn, a significant crop economically, and addresses the challenges posed by various corn leaf diseases. Advanced image processing methodologies, such as image acquisition, preprocessing, segmentation, and feature extraction, are utilized to enhance disease identification accuracy. Techniques like color transformation, noise removal, k-means clustering, and Otsu's thresholding are employed to segment and analyze affected leaf areas.

Keywords: Image Processing, Leaf Disease Detection, Corn Diseases, CNN, Feature Extraction, Segmentation

Introduction

The productivity of agriculture is the main driver of the Indian economy. Agriculture supports more than 70% of rural households. More than 60% of people are employed in agriculture, which contributes roughly 17% of the GDP.[1] Therefore, in the field of agriculture, the detection of plant diseases is crucial. Indian agriculture consists of a variety of crops, including wheat and rice. In addition, Indian farmers cultivate potatoes, sugarcane, oilseeds, and non-food products like cotton, rubber, tea, and coffee.[2] The strength of the roots and leaves determines how each of these crops grows. Plant disease detection can be accomplished through the use of image processing tools. Disease symptoms are typically observed on the fruit, leaves, and stem. The leaf that exhibits the signs of the disease is taken into consideration for disease detection. The image processing method utilised to identify leaf disease is introduced in this publication.[3,4]

Purpose

Among the three provinces in the northeast, maize is one of the most significant economic crops. Since China has a large population, it is imperative to increase maize output. The incidence of maize diseases is on the rise, which has a significant impact on maize production. In addition to wasting resources like labour and materials, misdiagnosing diseases can easily result in the failure of preventative measures, delaying the best possibilities for prevention and control and perhaps causing disease epidemics and significant financial losses. In order to quickly construct the model and provide the necessary information, the image processing technology—such as image digitisation, image enhancement, image segmentation, and feature extraction—is used to obtain the identification information of maize disease based on a thorough understanding of the image information. The corresponding database is then established.

Different types of Corn leaf Diseases

The reason for this section is that researchers can understand type of image processing operation and type of feature need to be considered by observing various diseases.

There are five types of corn leaf diseases:

- Fungal Diseases
- Bacterial Diseases
- Viral Diseases
- Nematode Diseases
- Physiological Diseases

The given difference having there sub-parts:

Fungal Diseases

- Northern Corn Leaf Blight (NCLB) Caused by the fungus Exserohilum turcicum, it leads to elongated lesions with dark brown borders on corn leaves.
- Gray leaf Spot (GLS): Caused by the fungus Cercospora,zeae-maydis, it results in small, rectangular lesions on leaves that turn grey and then tan(fig 1).

Bacterial Diseases

Bacterial Leaf steak:Caused by the bacterium Xanthomonas vasicola pv. zeae, it leads to narrow, elongated lesions on corn leaves (fig 2).

Bacterial Wilt: Caused by the bacterium Erwinia tracheiphila, it results in wilting and yellowing of leaves and eventual plant death.

Viral Diseases

Maize Dwarf Mosaics Virus (MDMV): Transmitted by aphids, it causes stunted growth, mosaic patterns, and yellowing of leaves.

Maize chlorotic Mottle Virus (MCMV): cause chlorotic mottling and streaking n a leaves. c. Maize steak virus (MSV): Transmitted by leafhoppers, it leads to stunted growth and chlorotic streaks on leaves (fig 3).

Nematode Diseases

- **Root-Knot Nematode:** Caused by various species of nematodes, it results in the formation of galls on roots, leading to reduced nutrient uptake and stunted growth.
- **Lesion Nematode:** Causes necrotic lesions on roots, affecting water and nutrient uptake (fig 4).

Physiological Diseases

- **Common smut:** Caused by the fungus Ustilago maydis, it results in large, gray-black galls on various plant parts, including leaves, stems, and ears.
- **Corn Smut:** Another type of smut caused by the fungus Setosphaeria turcica, it lead to lesion on leaves, tassels and ears (fig 5).

Basic Steps For Disease Detection And Classification.

- This section outlines the fundamental procedures for classifying and detecting plant diseases through image processing Fig 6 fundamental procedures for classifying and detecting plant diseases through image processing.

Figure 1.Fungal Diseases

Figure 2.Bacterial Diseases

Figure 3.Viral Diseases

Figure 4.Nematode Diseases

Figure 5.Physiological Diseases

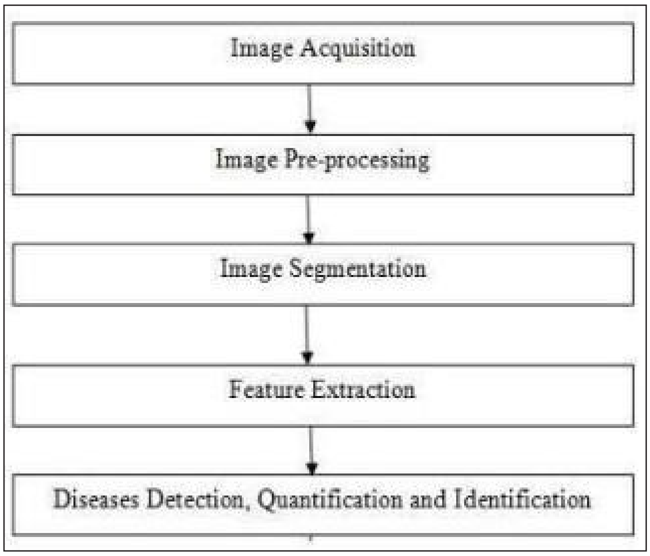

Figure 6.Fundamental procedures for classifying and detecting plant diseases

Image Acquisition

The camera is used to take pictures of the plant leaf. Red, green, and blue make up this image's RGB format. Following the creation of a colour transformation structure for the RGB leaf picture, a device-independent colour space transformation is applied.

Image Pre-processing

Various preprocessing methods are taken into consideration in order to eliminate noise from images or other objects. Image clipping is the process of trimming a leaf image to obtain the desired image section. The smoothing filter is used to smooth images. The purpose of image enhancement is to increase contrast. Equation (1) is used to convert the RGB images into greyscale images. f(x)=0.2989*R + 0.5870*G + 0.114.*B --------(1) To improve the photos of plant diseases, the histogram equalisation is then done, which divides the image intensities. Intensity Segmentation: values are distributed using the cumulative distribution function.[5,6]

Image

- Segmentation is the process of dividing an image into different areas that share characteristics or are somewhat similar. Numerous techniques, such as the otsu method, k-means clustering, RGB picture conversion to HIS model, etc., can be used for segmentation (fig 6).
- The RGB image is transformed into the HIS model for segmentation utilising the boundary and spot detection technique. As mentioned in, boundary detection and spot detection aid in locating the leaf's contaminated area. The boundary detection algorithm is used for border detection, taking into account the eight pixel connectedness.
- **K-means clustering:** K-means clustering divides an object into K classes according to a collection of features. By minimising the sum of the squares of the distance between the object and the matching cluster, objects are categorised. The K-means algorithm is

Clustering

- Choose the K cluster's centre at random or using a heuristic.
- Assign each image pixel to the cluster that has the smallest separation between it and the cluster centre.
- Once more, average all of the cluster's pixels to get the cluster centres. Continue steps two and three until convergence is achieved.
- **Otsu Threshold Algorithm:** This algorithm sets all pixels below a threshold to zero and all pixels above that threshold to one in order to produce binary pictures from grey-level images. The following is the Otsu algorithm as described in:
- Based on the threshold, Divide the pixels into two groups.
- Next, determine each cluster's mean. Calculate the square of the mean difference.
- Multiply the number of pixels in one cluster times the number in the other 769 The infected leaf shows the symptoms of the disease by changing the color of the leaf. Hence the greenness of the leaves can be used for the detection of the infected portion of the leaf. The R, G and B component are extracted from the image. The threshold is calculated using the Otsu's method. Then

the green pixels is masked and removed if the green pixel intensities are less than the computed threshold.

- **Feature Extraction:** Feature extraction plays an important role for identification of an object. In many applications of image processing feature extraction is used. Color, texture, morphology, edges etc. are the features which can be used in plant disease detection. In paper, Monica jhuria et al considers color, texture and morphology as a feature for disease detection. They have found that morphological result gives better result than the other features. Texture means how the colour is distributed in the image, the roughness, hardness of the image. It can also be used for the detection of infected plant areas.
- **Color co-occurrence Method :** In this method both color and texture are taken into account to get an unique features for that image. For that the RGB image is converted into the HSI translation.

$$\begin{cases} H = \begin{cases} \theta & B \le G \\ 360 - \theta & B > G \end{cases} \\ S = 1 - \dfrac{3}{(R+G+B)}[\min(R,G,B)] \\ I = \dfrac{1}{3}(R+G+B) \end{cases}$$

- **For the texture statistics computation the SGDM matrix is generated and using GLCM function the feature is calculated. 3. Leaf color extraction using H and B components:** The input image is enhanced by using anisotropic diffusion technique to preserve the information of the affected pixels before separating the color from the background. To distinguish between grape leaf and the nongrape leaf part, H and B components from HIS and LAB color space is considered. A SOFM with back propagation neural network is implemented to recognize colors of disease leaf. Some potential areas of advancement:
- **Integration of Advanced Machine Learning Models:** Utilizing more sophisticated models like Transformer-based architectures or advanced versions of convolutional neural networks (CNNs) to improve accuracy and efficiency in disease detection.
- **Real-Time Detection and Mobile Applications:** Developing mobile or edge computing applications that allow real-time disease detection directly in the field, reducing the need for manual sample collection and lab analysis.
- **Cross-Crop Disease Detection:** Expanding the system to detect diseases in a wider variety of crops, utilizing transfer learning to adapt existing models for different plant species.
- **Multispectral and Hyperspectral Imaging:** Incorporating multispectral and hyperspectral imaging to capture a broader range of wavelengths, which could provide more detailed information about plant health and disease symptoms.
- **Data Augmentation and Synthesis:** Addressing the challenge of limited datasets by employing data augmentation techniques and synthetic data generation to improve model training and robustness.
- **Automated Disease Management Recommendations:** Extending the system to not only detect diseases but also provide automated recommendations for disease management, including suitable pesticide applications and cultural practices.

Conclusion

Successful crop cultivation depends on the precise identification and categorisation of maize leaf disease, which can be accomplished by image processing. Several methods for segmenting the plant's diseased portion were covered in this paper. In order to classify LEAF illnesses and extract the characteristics of affected leaves, this research also covered a few feature extraction and classification algorithms. CNN techniques including self-organising feature maps, back propagation algorithms, SVMs, etc., can be effectively used to the classification of plant diseases. With the help of image processing tools, we can reliably diagnose and categorise a variety of plant illnesses.

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