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Plant leaf disease detection using Curvelet transform

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Abstract
Early detection of Leaf disease is the most significant process in the agricultural applications to reduce the usage of fungicides in the agricultural field and to increase the quality and quantity of the product. To identify the plant diseases at an early stage is not yet explored. Existing disease detection techniques does not yield better performance due to the complex background and illumination variation. Hence, there arises a need for the development of effective disease identification technique. This paper proposes a novel wrapping based Curvelet transformation with texture feature extraction method for automatic detection and classification of plant leaf disease. In this paper, Adaptive Median Filter (AMF) is used for filtering the impulse noise from the image. Leaf image identification is performed using green pixel extraction and K-means clustering. Wrapping based Curvelet transform is applied to the leaf image. GLCM based feature extraction is performed to extract the texture pattern of the plant image. Then, the selected features are learned and passed through an RVM-based classifier to find out the disease. Edge detection and contouring is performed to identify the disease affected area in the leaf image. The proposed approach achieves higher accuracy for disease detection.

Keywords: Curvelet transformation, gray level co occurrence matrix (GLCM), relevance vector machine (RVM)

Introduction
Image processing plays an important role in our-day-to-day life and it has several applications. One of the applications of image processing in the field of agriculture is disease detection from the crop in order to improve the quality and the yield of the crop. Monitoring of disease occurrence on plant plays an important role in successful cultivation of crops. The image processing techniques can be used in the plant disease detection. This paper gives the novel image processing techniques for plant disease detection and classification. In the conventional cropping systems, disease can be managed by applying chemicals on the plants. However, this practice causes adverse effects on the environment and human health. In order to reduce the usage of chemicals, the distribution of disease in leaf is sensed automatically by using various approaches. This aids in the optimization of the application dosage of the chemicals in the plant.
Convolution neural network (CNN) is used for image recognition and classification of leaf diseases. (Malusi Sibiya, 2019) [1]. Wheat disease detection through leaf image and data processing techniques is used extensively to assist farmers in monitoring the big plantation area. (Dixi, 2018) [2]. Disease detection involves the steps like image acquisition, image pre-processing, image segmentation, feature extraction and classification. Plant disease in plants is classified using Image Processing and ANN such as self- organizing feature map, back propagation algorithm, SVM. From these methods, we can accurately identify and classify various plant diseases using image processing technique. In this it describes the uploaded pictures captured by the mobile phones are processed in the remote server and presented to an expert group for their opinion (Sachin and Sanjana. Y. 2015) [3]. Computer vision techniques are used for detection of affected spots from the image and their classification. A simple color difference based approach is followed for segmentation of the disease affected lesions. The system allows the expert to evaluate the analysis results and provide feedbacks to the famers through a notification to their mobile phones (Sanjay B and Bernardes, 2013) [5]. A method of mathematics morphology and texture, shape and color features of color image of disease spot on leaf were extracted, and a classification method of membership function was used to discriminate between the three types of diseases. Curvelet Transform and Tamura Texture Feature with RVM classification techniques has used for weed discrimination (D. Ashok Kumar and P. Prema. 2016) [7].

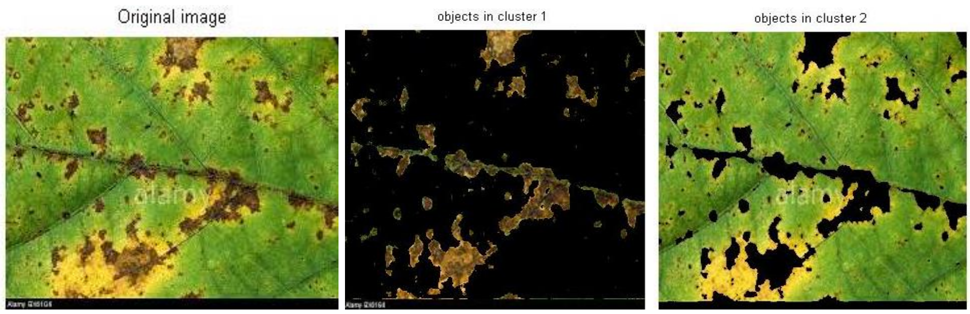
Materials and Methods

Wrapping based Curvelet Transformation and texture feature extraction method used for disease discrimination. Adaptive Median Filters the impulse noise and applies the smoothening effect to the image for the clear analysis of textures. Green pixel extraction and K-means clustering is applied to the filtered image, to cluster the soil and plant leaf of the image. Wrapping based curvelet transform is applied to represent the smooth edges and other singularities along the curve more efficiently than the wavelet transform. Wrapping based curvelet transform utilizes a series of translations to ensure faster computation capability. After applying the curvelet transformation, the angular based features are extracted from the transformed image. In the texture pattern analysis, an MWP system is used to predict and analyze the difference in texture in the image. Then, the selected features are learned and passed through an RVM-based classifier to find out the disease affected area. Canny-based Edge detection and contouring is performed based on the classification results, to identify the disease. Clear analysis and segmentation of the plant image in the complex background are achieved due to the angular texture pattern extraction at each windowing patch.

Preprocessing and Segmentation

Initially, disease affected datasheet image is considered as the input with RGB color value. Pre-processing of the disease infected leaf image is extracted by using the adaptive median filtering to remove the noise and correct the distortions in the image. Then, the image enhancement is performed using the Global Histogram Equalization (GHE) approach by distributing the intensity of the image. Then image intensity is restored to get enhanced image. This enhanced image is segmented using combined Modified ExGRB_KMean clustering approach.
Disease infected leaf image was extracted from the green pixel extraction is performed using the formula. Figure 1 shows the original image and disease segmentation image.

$$P_C=2G-R*G-B \qquad \text{---- (1)}$$



(a) (b) (c)

Fig 1: Original Image and Segmentation Image

P_C denotes the green pixel count. R, G, and B are the three components of pixel color in RGB color space. Combine the output of Green pixel value of P_C and K Mean Clustering Methods is used for Disease infected leaf image.

Curvelet transformation

Wrapping Curvelet Transform is applied to the plant image, to obtain the forward and backward Curvelet transformation. The image and Curvelet at a given scale and orientation are transformed into the Fourier domain, during FFT. A set of Curvelet coefficients is obtained by applying inverse FFT to the spectral product, at the completion of the computation process
The number of Curvelet decomposition levels for the Curvelet transform is determined using the following formula

$$N=\mathrm{Log}_2\big(\mathrm{Size}(M,1)\big)-2 \qquad \text{... (2)}$$

Where, ‘N’ is the number of levels and ‘M’ is the number of rows. The size of the plant image is 300×300. By applying the size in the eqn (2), the number of levels for the Curvelet transformation is 6. Hence, six levels of Curvelet decomposition are applied to the input image. Curvelet based feature extraction takes the raw or the preprocessed images as input. The Figure 1 shows the input to the Wrapping based Curvelet transformation and feature extraction process.
The images are then decomposed into Curvelet subbands in different scales and orientations. In disease classification two very close regions that have differing pixel values will give rise to edges; and these edges are typically curved for crop or weed. As Curvelet are good at approximation curved singularities, they are fit for extracting crucial edge-based features from images more efficiently than that compared to wavelet transform. The Curvelet decomposed images are called ‘Curvelet images’. The approximate Curvelet images contain the low-frequency components and the rest captures the high-frequency details along different orientations.
After applying inverse wrapping based Curvelet transformation, Figure 2 show the Curvelet transformed image.

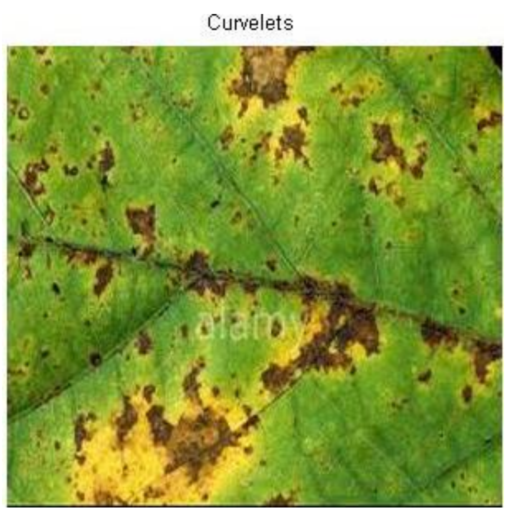


Fig 2: Curvelet transformed image

Feature extraction

Feature extraction is the process of defining a set of features, for the efficient representation of the information for analysis and classification for disease. In the Curvelet transformed image, healthy and disease affected regions are very close regions that have differing pixel values will give rise to edges; and these edges are typically curved for infected areas.In the feature extraction step, level 2 and level 5 sub-band coefficients are selected for the extraction of features in six-level Curvelet decomposition of the images. The level 2 coefficients include the finer details and level 5 coefficients include the coarse details of the image. In order to improve the feature extraction process, texture feature are used for leaf disease identification.

Tamura features

The Tamura features are extracted from the image. Tamura features are mainly used for texture analysis. The texture gives information regarding the spatial arrangement of color or intensities in a leaf image or selected region of a leaf image. The Tamura features characterize the low-level statistical properties of the images. Tamura features including coarseness, contrast, directionality, energy, entropy are extracted from the image. The following table 1 describes tamura texture features and its function.

Table 1: Texture Features and its function

Coarseness	Coarseness is a measure of the size of the texture elements. Fine textures have smaller coarse value than the coarse textures.
Contrast	Contrast defines the difference in the intensity value among the neighboring pixels. The image contrast is influenced by the dynamic range of gray levels in the image, polarization of the black and white distribution and sharpness of edges.
Directionality	Directionality measures the total degree of directionality, and also differentiates between the different orientations and patterns.
Energy	Energy is the measure of the uniformity in the gray distribution level of the image. The energy is high for the coarse texture.
Entropy	Entropy is the measure of the amount of the texture information of an image. If there is no texture information, then the entropy is zero.

In feature extraction process, after applying inverse Curvelet transformation, tamura features are obtained for each image and mean value of level 2 and level 5 Subband are obtained. Totally seven features extracted from the whole image.

RVM-Based classification

For a leaf disease discrimination system is divided into two stages: a training stage and a classification stage. In the training stage, a set of known leaf disease (labeled data) are used to create a representative feature-set or template. In the classification stage, an unknown leaf image is matched against the previously stored database by comparing the features.

Results and Discussion

The results of the proposed work Curvelet transform with enhanced tamura features are compared with existing methods of disease classification. In our proposed work in our work, Dataset includes the Real-time plant image obtained from the Agricultural field. The Dataset includes 50 images. From the data set, 30 images are used for training and 20 images are used for testing. The performance of the proposed approach is evaluated using a set of 50 images. The metrics used for evaluating the performance of the proposed approach are Accuracy. Accuracy is defined as the measure of the correct classification results of the weeds in the plant image.

Accuracy = $N_{TP}+N_{TN\,/\,(}N_{TP}+N_{TN}+N_{FF}+N_{FN)}$

Where NTP is the true positive measurement, NTN is the true negative measurement, NFP is the false positive measurement (a portion of the image incorrectly classified, and NFN is the false negative measurement (a portion of the image incorrectly classified as not a disease). The proposed approach achieves better performance in terms of the disease accuracy. The accuracy of the proposed approach is 95.45%. The proposed method show improving leaf disease classification quality against various lighting conditions and complex background. The Figure 6 shows the output image of the proposed disease detection from the plant leaf image extraction method.

Fig 3: Disease Detection output

Table 2: Comparative analysis of accuracy of the proposed and existing techniques

Comparative analysis of accuracy of the proposed and existing techniques Methods	**Accuracy (%)**
K-means clustering algorithm with SVM, color co-occurrence method.	88.89%
GLCM, SVM, K-means	90%
Proposed Curvelet with Tamura texture feature Extraction Method with RVM	95. 43%

The table2 highlights the comparative analysis of the accuracy of the proposed Curvelet transform with texture extraction method with RVM with existing techniques. The proposed method is compared with the existing K-means clustering algorithm with SVM approach for disease detection of in plant leaf. The overall accuracy of the proposed approach is 95.43%, which is relatively higher than the existing techniques. Hence, the proposed approach is found to be efficient than the existing techniques.

Conclusion and future work

A novel Curvelet transformation and feature extraction method for disease identification was proposed in this paper. For the pre-processing operation, Adaptive Median Filter is used to filter the noise from the leaf image. Leaf image identification is performed using green pixel extraction and K-means clustering. Wrapping based Curvelet transform is applied to the leaf image. Tamura feature extraction is performed to extract the texture pattern of the plant image. Then, the selected features are learned and passed through an RVM-based classifier to find out the disease. Edge detection and contouring is performed to identify the disease affected area in the leaf image. Clear analysis and segmentation of the disease affected area from the leaf image in the complex background are achieved due to the Curvelet transformation and tamura texture features. The proposed approach achieves better performance in terms of Accuracy. In our future work, Fuzzy rule based system is required to estimate the disease level estimation and real time spraying technique based on the infected area.

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