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# Integrated Analysis of Tomato Plant leaf disease disorder using improved Machine Learning approach

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## ABSTRACT

The idea behind the paper is to bring awareness amongst the farmers about the cutting-edge technologies to reduces diseases in plant leaf. Since tomato is merely available vegetable, the approaches of machine learning algorithms is identified to detect the leaf diseases in the tomato plant. In this investigation, the samples of tomato leaves having disorders are considered. With these disorder samples of tomato leaves, the farmers will easily find the diseases based on the early symptoms. Firstly, the samples of tomato leaves are resized to 256x256 pixels and then Histogram Equalization is used to improve the quality of tomato samples. The K-means clustering is introduced for partitioning of dataspace into Voronoi cells. The boundary of leaf samples is extracted using contour tracing. The multiple descriptors viz., Discrete Wavelet Transform, Principal Component Analysis and Grey Level Co-occurrence Matrix are used to extract the informative features of the leaf samples. Finally, the extracted features are classified using machine learning approaches such as SVM, CNN and K-NN. The accuracy of the proposed model is tested better for CNN on tomato disordered samples.

***Keywords:*** Histogram Equalization, Discrete Wavelet Transform, Principal Component Analysis, Convolutional Neural Network, Leaf Diseases.

## 1. INTRODUCTION

Agriculture is the backbone of our country’s economy. It is not just the source of food but also source of national economy. Crops are harvested in acres of area and the family income in most of the places depends just on the crop yield. Floods, pollution, leaf diseases, pests, bacteria, fungus, etc., hinder the crop yield. Most of these can be controlled and to certain extent avoided provided the source is found in initial stage so that necessary precautions can be taken. Early detection of crop diseases is important [1]. Most of the crop diseases occur when their leaves are affected by pests or other insects and pollutants. If attention is not provided to crop diseases in initial stage, then the entire yield will be a waste and huge losses are incurred. Cases of farmers committing suicides when the yield is less have risen tremendously in the past decade. Currently leaf diseases are detected by agriculture experts by manual examination [2]. This is a time-consuming process and costly. Easy access to such personnel is not available to the farmers. Farmers will be burdened with costly manures and fertilizers, and it is out of their reach most of the time. Therefore, there is a need to come up with the image processing tools and machine learning algorithms which will speed up this process of crop detection and help farmers get good yield and money for their harvested crops. If early detection of plant disease is not detected by farmers, then growth of disease exceeds its primary stage and destroys complete crop which in-turn affects economic benefit to the farmer. In plants, some of the common symptoms are discussed in this section.Bacterial disease symptoms: It is characterized by tiny pale green spots, where the lesions appears to be dry spots. Bacterial disease on plant which intern reduces the production is shown in Figure1.

Figure 1. Figure 2. Figure 3. Figure 4.Figure 5.

Viral disease symptoms: Diseases caused by viruses are not easier for diagnoising the leaf. These viruses will not produce any of the telltale signs and are often confused with nutrient deficiency and herbicide injury. Most of the times insects carriers for generation of disease [4]. The sample of viral disease leaf is shown in Figure 2. It appears as yellowish/green stripes on foliage. The wrinkled and curled shapes is noticed for the diseased leaf.Fungal disease: The fungus for leaf images are shown in Figure 3, 4 and 5 respectively. The late blight is caused by Phytophthora infester which appears initially on lower and older leaves (water-soaked, gray-green spots). When disease matures, these gray-green spots darken and then there will be formation of white fungal growth on the undersides of the leaf [5].It is caused due to solani, that appears initially on lower and older leaves. When fungal disease matures, possibly it will spread at the position of outer section of the leaf surface and results in yellow color [6]. The sample of early blight leaf image is shown in Figure 4. In case of disease due to downy mildew, an upper surface of older leaves appears to be yellow to white patches on the leaf images. Probably, such areas are accumulated with white to grayish color on the outer sections of the leaf images [7]. The sample of downy mildew is shown in Figure 5.

In classical approach, recognition of plant disease was based on observations such as which leads slow process and produces lower accuracy. This limitation was overcome by consulting the experts for detection of diseases on leaf [8]. This result in more expensive and time consuming. Due to irregular diagnosis of plants, they may suffer from many diseases. Because of various diseases, the plants require more chemicals to cure. Using chemicals on plants and fruits are more toxic as it affects to animals, insects, and birds. So, to overcome the limitations faced by most of the farmers, early diagnosis of plant disease is essential and primary task in agriculture field and intern the farmers need continuous monitoring of known peoples which may become more expensive and time consuming [9]. Hence robust methodology to detect the diseases automatically based on their symptoms. This enables the model that performs automatic inspection of the leaf, controlling the activities during its process and robot guidance. The model using image processing techniques can be applied on different applications for detection of leaf, stem, and fruit diseases of plants. In addition, it helps to find affected area. Also, it determines the color, size, and shape of the fruits [10].

## 2. LITERATURE SURVEY

Lot of work has been devoted to the detection of leaf diseases based on computer vision in the history and it continues to attract research to carry out their research work in this field. Government is keen on taking up several projects which will address this issue. Automatic crop disease detection using computer vision and machine learning algorithms has been gaining prominence in recent years.

Revathi et al., [1] developed algorithms to identify the diseases using infected images. The homogeneous pixel technique on cotton plant disease detection was implemented. The K-means Clustering and NN is used for segmentation and classifier respectively to detect the disease. Samples of cotton leaves are used to evaluate the model. Kiran et al., [2] uses the images of various acquired with camera having better quality. The color space conversion was carried out in the work. The K-means clustering and GLCM is used for segmentation and feature extraction purpose, SVM is used as a classifier. Jagadeesh et al., [3] developed algorithm using crop disease prediction. The GLCM and GLRLM are used for feature extraction. Usama et al., [5] discussed Gabor transform and Gabor wavelet and image resizing, and background removal also done. Gabor filters was applied on the images for feature extraction.Vaijai Singh et al., [6] predicted early leaf disease detection. Gabor filter and K-Means model is used to segment the leaf and the techniques such as SVM, ANN are used for classification process.Sachin et al., [8] considered the images which is in the form of RGB. The K-Mean Clustering based on the Otsu threshold is used for segmentation. The GLCM helped to extract the significant features. The ANN and back propagation are used to classify the leaf whether healthy or not healthy. Priti et al., [9] used spatial filter, GLCM and SVM classifier for detection of leaf disease. Padol et al., [11] Gaussian filtering is approached to denoise in the image, downy mildew color feature and powdery mildew for feature selection, LSVM classification is used for matching. Rajan et al., [12] GLCM features are used in the experimentation. The color space components are used to identify the characteristics of an image. The SVM is used for classification. Morphological operations like dilation and erosion, opening and closing are used.

Pallavi et al., [15] used RGB to HIS conversion and bank of filters for enhancement. SVM is used for classification of leaf. Sandesh et al., [16] used GLCM and multi-linear SVM for extraction of leaf features and classification respectively for detection of leaf disease. Monzurul Islam et al., [17] used linear SVM to classify the leaf disease. The GLCM is used as a feature extraction of leaf images. P Krithika et al., [19] The K-Means clustering for segmentation and feature extraction using GLCM is performed. Classification was made using multiclass SVM. Meena Prakash et al., [20] performed the conversion from RGB images into L*A*B* color space. The K-Mean clustering algorithm and GLCM is used for features selection. Bharat et al., [21] acquired images using digital camera and median filter is used for image enhancement. The K-Mean clustering is performed for segmentation and SVM is used for classification.Pooja V et al.,[22] segmentation is done to get the areas of interest that is the infected region. It is done using k-Mean clustering, Otsu's detection converting RGB to HSI later segmentation is done spot detection algorithm. Rukaiyya P. Shaikh et al., [23] performed pre-processing by contrast adjustment and normalization. Later, segmentation is carried out using color transform. The significant features are extracted using GLCM and HMM is considered for classify the samples. Chaitali et al., [25] the concept of background subtraction was implemented during segmenting the images. The SVM, ANN and KNN is used for classifying the samples. Varun et al., [27] has developed model for extraction thresholding technique and morphological operation. Then multiclass SVM is used as classifier.

Vijai Singh et al., [28] have proposed image segmentation algorithm. Images of plant leaves having bacterial diseases like rose, lemon leaf, beans leaf, banana leaf and beans leaf are captured. The green regions as background using thresholding algorithm. Finally, the genetic algorithm is used to get the segmented image. Color co-occurrence method is used to extract useful features from the segmented images and SVM classifier. Sa'ed Abed et al., [30] segmented is followed using K-Means clustering with ED to extract the region of intercept from the image. Later the GLCM will be used for feature extraction. The feature vector is classified using SVM classifier. Arya et al., [31] takes input RGB image and creates color transformation then conversion of RGB to HIS format is carried out in the model. Finally, segment the components using Otsu's method. Nema et al., [33] images of 81 were included in the database and analysis was performed in L*a*b color space. The segmentation was done using k-means clustering and the classification of the disease was performed using support vector machine technique. Statistical information such as mean, median, mode, standard deviation was used by authors to record their findings. Pushpa et al., [35] considered Histogram technique based on indices to segment unhealthy region of the leaf. It surpasses other segmentation techniques such as slice segmentation, polygon approximation, and mean-shift segmentation. Kaleem et al., [36] considered preprocessed to resize them into 300*300 sized images, remove background noise, enhance brightness, and adjust the contrast. Segmentation is carried by K-means clustering. The key issues and challenges are identified by the researchers and the scientists, while analyzing the leaf diseases of plant. Some of them are as follows: The quality of the leaf image must be high, Publicly available Dataset requirement, Noisy data affecting the leaf samples, Through the process of segmentation, diseases may be identified but the samples must undergo training and testing, Classification is one more challenge, in the stage of detecting the leaf diseases, Color ofthe leaves may be varied du to environmental effect, Monitoring of plants needs to do on daily basis to observe the changes, Variety of diseases can be seen in various kinds of plants, so detection of disease is quite difficult.

Based on the challenges discussed above, combined techniques based on the machine learning algorithms, proposed models provide better accuracy. This motivates to carry out the proposed work in the field of agriculture. Keeping all these things in mind, a robust algorithm based on machine learning tools to automatically detect leaf diseases is proposed in this investigation.The rest of the paper is arranged as follows. Section 2 presents a related work on leaf disease detection. Section 3 brings out the proposed model and its algorithm. The experimental results and its analysis are made on proposed methodology are discussed in section 4. Lastly, conclusion of the research work is done in section 5.

## 3. PROPOSED METHODOLOGY

The proposed model based on the computer vision and machine learning approaches to detect the leaf disease in presented in this section. The proposed model is shown in Figure 6.

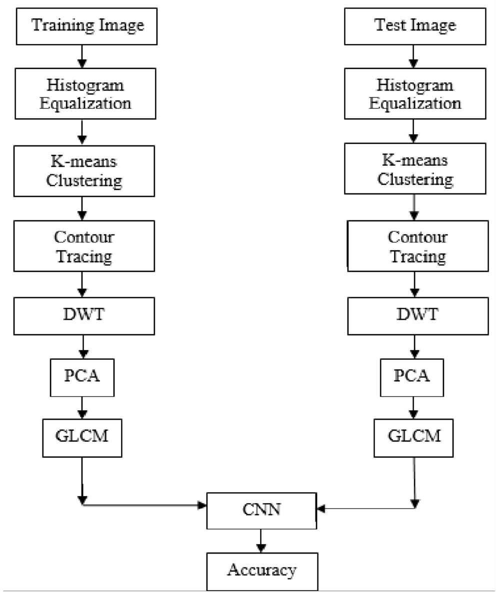



Figure 6. Proposed model

The tomato samples having six disorders are considered to evaluate the performance of the model and to recognize the leaf disease as Healthy or Unhealthy. As a part of image processing, the samples of tomato are resized to 256x256 pixels to maintain equal in their size throughout the experiment. The HE and K-means clustering are employed to maximize the quality and segment the leaf samples. Based on the K-means clustering response, the leaf is diseased or not can be predicted at the early stage of operation. The boundaries of the leaf samples can be extracted using contour tracing. The DWT, PCA and GLCM are considered to extract the informative regions/features of the samples. In the next stage as a part of machine learning approaches are used to classify the features and the performance of the model is recorded.

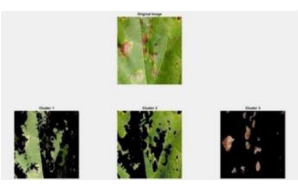
| | |
|---|---|
| $f1 = \sum_{i,j} \frac{p(i,j)}{1+\|i-j\|}$ | (1) |
| $f2 = \sum\sum(i,j)p(i,j)$ | (2) |
| $f3 = \sum_i \sum_j (i + j - \mu x - \mu y)^3 p(i,j)$ | (3) |
| $f4 = \sum_i \sum_j \|i - j\| p(i,j)$ | (4) |
| $f5 = \sum_i \sum_j (i - \mu)^2 p(i,j)$ | (5) |
| $f6 = \sum_{i=2}^{2N_g} i p_{x,y}(i)$ | (6) |
| $f7 = \sum_{i=2}^{2N_g} (1 - fs)^2 p_{x+y}(i)$ | (7) |
| $f8 = -\sum_{i=2}^{2N_g} i p_{x+y}(i) \log p_{x+y}(i)$ | (8) |
| $f9 = \frac{HXY - HXY_1}{\max(HX,HY)}$ | (9) |

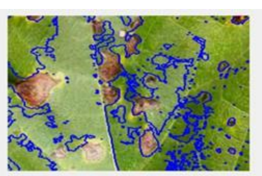
***Database:*** The village database of tomato leaf [21] is considered, the plants which are affected from variety of diseases. The images of tomato leaf having si disorders are taken to carry out the experiments for detection of leaf disease. The samples of leaf images in the database are shown in Figure 7.

Figure 7. Samples of leaf imagesFigure 8. Pre-processed image

***Pre-processing:*** K-means clustering technique [22] is applied on leaf images to find out the infected region. The K-mean clustering is used to get the data Centre of the image and make the clusters of that image and calculates the Centre distance from the other cluster. Samples of leaf after applying k-mean clustering algorithm [23] is shown in Figure 9.

**Contour tracing** [24] is performed on digital leaf samples to extract their general shape information. After extracting the contour, its characteristics is analyzed and used for pattern classification. It often helps for determining the efficiency of feature extraction process. The images appeared after performing contour tracing is shown in Figure 10.





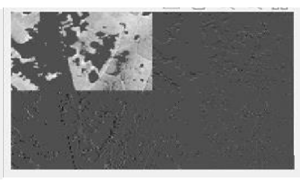


Figure 9. K-mean clusteringFigure 10. Contour TracingFigure 11. DWT Decomposition

**Discrete Wavelet Transform:** The DWT [25] is applied on enhanced tomato samples to extract the useful features of the tomato leaf. Later, the DWT decomposes into four sub-bands consisting of three lower (LL, LH, HL) and one higher frequency (HH) components. The LL component of DWT carries maximum availability of information when compared with higher frequency components of DWT as shown in Figure 11.

***Gray Level Co-occurrence Matrix:*** The optimal features are selected obtained from wavelet decomposition is carried out by Principal Component Analysis [26]. The GLCM uses in the distribution of higher order of gray values that are defined with neighborhood criterion. The several properties are derived from the GLCM technique for extraction of leaf features. The most used texture-based features are as follows. Homogeneity, Autocorrelation, Dissimilarity, Entropy, Sum of squares, Average, Variance, Entropy [27-28]. The features obtained using DWT, GLCM and PCA are combined to form feature vector which are made available as an input sample to the classifiers to recognize classify the images.The most commonly used texture-based features are as follows.

**Homogeneity:** In this case, closeness distribution of elements in GLCM to its diagonal value comprising in the range of [0, 1] is measured. Its value is unity for the coefficients that are placed in diagonal in GLCM and is given in equation 1.**Autocorrelation:** This feature is used to evaluate the fitness of the texture accumulated in image and is given in equation 2.**Dissimilarity:** This feature measures the degree of smoothness in a texture and is given in equation 3.

**Entropy:** This feature measures the statistical randomness to characterize the texture of image and is given in equation 4.**Sum of squares:** This provides high weight on elements which differs from average value of p (i, j) and is given in equation 5.**Sum Average:** Ratio of sum of all values to the total number of values and is given in equation 6.**Sum Variance:** It is the measure of separated values around mean and combinations of reference and neighbor pixels and is given in equation 7.**Sum Entropy:** It is calculated as the summation for all pixel values and is given in equation 8.**Information measure of correlation 1:** Its feature calculation is given in equation 9.The features obtained using DWT, GLCM and PCA are combined to form feature vector which are provided as an input to the classifiers to recognize classify the images.

***Classification:***The SVM, KNN and CNN are used to carry out the classification on leaf samples. Based on the samples trained and tested, the decision will be made weather Healthy leaf or Unhealthy. The CNN [29-30] is a nothing but ANN that specifically designed in this mechanism. Intensionaly, it will be made possible to process the pixel data. The CNN is consisting of three important components such as input, output and multiple hidden layers [31-33]. The hidden layers typically consists of convolutional layers [34], RELU layer and normalization layers [35]. Mathematically it has more significance for the indices in the matrix. Regular 3-layer network [36-37] is shown in Figure 12.

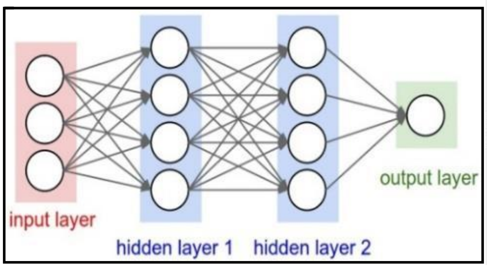




Figure 12. A regular 3-layer Neural NetworkFigure 13. CNN Confusion Matrix

The confusion matrix for CNN having output class and target class is shown in Figure 13. The progress of training samples of leaf features classified using CNN to know the accuracy and error for thirty numbers of iterations are shown in Figure 14. The CNN curve for MSE with number of iterations is plotted in Figure 15.

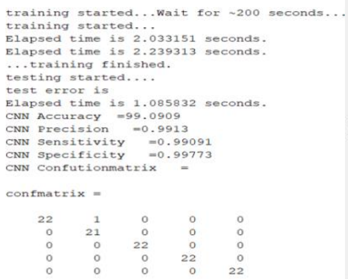



Figure 14. Performance of CNN Classifier

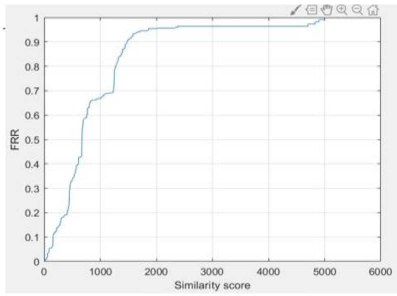



Figure 15. FRR v/s Similarity Score

## 4. RESULTS AND ANALYSIS

The samples of tomato leaf of village dataset is considered to carry out to evaluate the proposed model. The 100 samples of healthy leaf is taken to test on the proposed model. The model results in idetifying 99 samples with an accuracy of 99%. In the 100 Mosaic virus tomato samples, the model recognizes 100 samples with an accuracy of 100%. For leaf mold category, the model results in the accuracy of 100%. For the 100 samples of yellow curl, the model performed 99%. Similarly, the Spotted spider mite and Target Spot results in 99% and 100% respectively. Overall, 600 samples of tomato village dataset is tested on the proposed model for evaluation, as a result, the model provides an better accuracy of 99.5%.The model is validated by training/testing the dataset samples. The hardware and software specifications are recommended to carry out the work. ie., operation system: Windows10, Core: GPU-NVIDIA, language: Python, Libraries: Image data generator, Open Cv, Kera's, tensor flow, NumPy, Mat plot, Dataset: Plant village dataset having Tomato samples (Six disorder). Based on the parameters viz., Precision, Recall and F1 scores are used to evaluate the performance. The proposed model is tested on tomato leaf disease dataset with an overall 600 samples. Figure 16 shows the comparison ofproposed DWT+PCA+GLCM+CNN model with state-of-the-art method. The precession, recall and F1-scores of various classifiers are tabulated in Table 1.

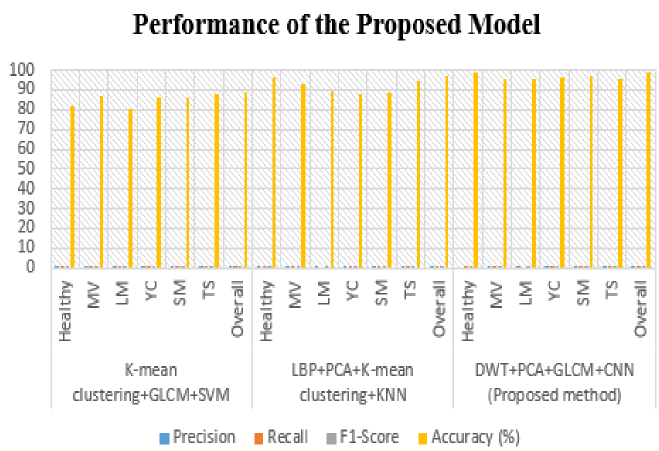



Figure 16. Comparison of Proposed model

Table 1: The precession, recall and F1-scores of various classifiers

| K mean clustering + GLCM + ED | | | | | LBP+PCA+NN | | | | DWT+PCA+GLCM+CNN **(Proposed method)** | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Healthy | 0.983 | 0.834 | 0.881 | 81.9 | 0.983 | 0.834 | 0.881 | 81.9 | 0. 98 | 0.984 | 0.979 | 98.9 |
| MV | 0.913 | 0.722 | 0.821 | 86.8 | 0.913 | 0.722 | 0.821 | 86.8 | 0.949 | 0.945 | 0.962 | 95.3 |
| LM | 0.895 | 0.817 | 0.896 | 80.2 | 0.895 | 0.817 | 0.896 | 80.2 | 0.932 | 0.934 | 0.956 | 95.5 |
| YC | 0.811 | 0.889 | 0.992 | 86.3 | 0.811 | 0.889 | 0.992 | 86.3 | 0.938 | 0.968 | 0.979 | 96.4 |
| SM | 0.977 | 0.861 | 0.985 | 85.9 | 0.977 | 0.861 | 0.985 | 85.9 | 0.953 | 0.919 | 0.899 | 97.2 |
| TS | 0.987 | 0.898 | 0.994 | 87.9 | 0.987 | 0.898 | 0.994 | 87.9 | 0.967 | 0.978 | 0.898 | 95.5 |
| **Overall** | **0.967** | **0.978** | **0.915** | **89** | **0.967** | **0.978** | **0.915** | **89** | **0.995** | **0.995** | **0.988** | **99.09** |

Table 2 shows the comparison of various techniques for detection of leaf disease is tabulated as compared with other state-of-the-art methods. It is noticed that accuracy of Proposed model producesbetter and is recorded 99.09% compared to the other existing models.The proposed model ML classification technique is compared with the methodology explained by Hossain et al., [32] and Vidyashree et al., [34] and Thanjai Vadivel et al., [37]. The accuracy of the proposed method seeks better as compared with the existing methodologies.

Table 2: Comparison of existing methodologies with proposed model

| Authors | Methodologies/Descriptions | Accuracy (%) |
|---:|---:|---:|
| Hossain et al., [32] | Statistical features test + SVM | 90.5 |
| Vidyashree et al., [34] | K-mean clustering + GLCM + SVM | 90 |
| Thanjai Vadivel et al., [37] | Fast Enhanced Learning Method | 98 |
| **Proposed Model** | **DWT+PCA+GLCM+CNN** | **99** |

## 5. CONCLUSION AND FUTURE SCOPE

The article is mainly focused on the early detection of the leaf disease by predicting the symptoms of disease and helps the farmers to increase the yield of crops in large production. In this investigation, the tomato samples having six disorders are considered to carry out the overall research. The proposed model uses image processing techniques including RGB conversion to gray, HE, clustering by K-means, contour tracing is employed in preprocessing stage. The DWT, PCA and GLCM statistical models are used to extract the informative features of the leaf samples. The machine learning approaches such as SVM, K-NN and CNN are used to classify the leaf samples to distinguish diseased or non-diseased. The analysis of the proposed model is well suited for CNN machine learning classification technique with a desired accuracy. The model can be improved using fusion techniques for extraction of significant features and examined for other leaf samples of datasets.

## REFERENCES


[1] P Revathi and M Hemalatha, "Classification of Cotton Leaf Spot Diseases Using Image Processing Edge Detection Techniques", *IEEE International Conference on Emerging Trends in Science, Engineering and Technology*, pp. 169-173, 2012.

[2] Kiran Gavhale, Gawande and Hajari, "Unhealthy Region of Citrus Leaf Detection Using Image Processing Techniques", *IEEE International Conference for Convergence of Technology*, pp. 1-6, 2014.

[3] Jagadeesh, R Yakkundimath and A Byadgi, "Identification and Classification of Fungal disease Affected on Agriculture/Horticulture Crops using Image Processing Techniques", *IEEE International Conference on Computational Intelligence and Computing Research*, pp. 1-4, 2014.

[4] Xiaobo Zhang, XiangchuFeng,"Hybrid gradient-domain image denoising", *AEU - International Journal of Electronics and Communications*, vol. 68, no. 3, pp. 179-185, 2014.

[5] U Mokhtar, Mona Ali, A Hassenian and H Hefny, "Tomato leaves diseases detection approach based on support vector machines", *IEEE International Computer Engineering Conference*, pp. 246-250, 2015.

[6] V Singh, Varsha and A Misra, "Detection of unhealthy region of plant Leaves using Image Processing and Genetic Algorithm", *IEEE International Conference on Advances in Computer Engineering and Applications,* pp. 1028-1032, 2015.

[7] Xianquan Zhang, Feng Ding, Zhenjun Tang, Chunqiang Yu, "Salt and pepper noise removal with image inpainting", *AEU - International Journal of Electronics and Communications*, vol. 69, no.1, pp.307-313, 2015.

[8] S Khirade and A Patil, "Plant Disease Detection Using Image Processing", *IEEE International Conference on Computing Communication Control and Automation*, pp. 768-771, 2015.

[9] P Badar and Suchitra, "Disease detection of pomegranate plant using image processing", *International Journal of Computer Science and Mobile Computing*, vol. 5, no. 5, pp. 328-334, 2016.

[10] A Joshi and B D Jadhav, "Monitoring and controlling rice diseases using image processing techniques", *International Conference on Computing, Analytics and Security Trends*, pp. 471-476, 2016.

[11] P Padol and A Yadav, "SVM Classifier Based Grape Leaf Disease Detection", *IEEE International Conference on Advances in Signal Processing*, pp. 175-179, 2016.

[12] P Rajan, Radhakrishnan and L Suresh, "Detection and Classification of Pests from Crop Images Using Support Vector Machine", *IEEE International Conference on Emerging Technological Trends,* pp. 1-6, 2016.

[13] S Jagtap and Shailesh, "Agricultural plant leaf disease detection and diagnosis using image processing based on morphological feature extraction", *IOSR Journal of VLSI and Signal Processing*, vol. 4, no. 5, pp. 24-30, 2016.

[14] Xiaobo Zhang, Shunli Zhang, "Diffusion scheme using mean filter and wavelet coefficient magnitude for image denoising", *AEU - International Journal of Electronics and Communications*, vol.70, no 7, pp. 2016.

[15] P Marathe, "Plant disease detection using digital image processing and GSM", *International Journal of Engineering Science and Computing*, vol. 7, no. 4, pp. 10513-10515, 2017.

[16] S Raut and A Fulsunge, "Plant disease detection in image processing using

MATLAB", *International Journal of Innovative Research in Science, Engineering and Technology*, vol. 6, no. 6, pp. 10373-10381, 2017.

[17] M Islam, D K Wahid, "Detection of potato diseases using image segmentation and multiclass Support Vector Machine", *IEEE Canadian Conference on Electrical and Computer Engineering*, pp. 1-4, 2017.

[18] N Agrawal, J Singhai and D K Agarwal, "Grape Leaf Disease Detection and classification Using Multi-class Support Vector Machine", *IEEE Proceeding International conference on Recent Innovations is Signal Processing and Embedded Systems*, pp. 238-244, 2017.

[19] P Krithika and S Veni, "Leaf Disease Detection on Cucumber Leaves Using Multiclass Support Vector Machine", *IEEE International Conference on Wireless Communications, Signal Processing and Networking*, pp. 1276-1281, 2017.

[20] R Prakash and G P Saraswathy and G Ramalakshmi, "Detection of Leaf Diseases and Classification using Digital Image Processing", *IEEE International Conference on Innovations in Information, Embedded and Communication Systems*, pp. 1-4, 2017.

[21] B Mishra, S Nema, M Lambert and S Nema, "Recent Technologies of Leaf Disease Detection using Image Processing Approach-Review", *IEEE International Conference on Innovations in Information, Embedded and Communication Systems,* pp. 1-5, 2017.

[22] Pooja V, R Das and Kanchana V, "Identification of Plant Leaf Diseases using Image Processing Techniques", *IEEE International Conference on Technological Innovations in ICT for Agriculture and Rural Development,* pp. 130-133, 2017.

[23] R P Shaikh and S A Dhole, "Citrus Leaf Unhealthy Region Detection by using Image Processing Technique", *IEEE International Conference on Electronics, Communication and Aerospace Technology,* pp. 420-423, 2017.

*[24]* Dataset Kaggle, https://www.kaggle.com/thanjaivadivelm

[25] Chaitali G Dhaware and K H Wanjale, "A Modern Approach for Plant Leaf Disease Classification Which Depends on Leaf Image Processing", *IEEE International Conference on Computer Communication and Informatics,* pp.12-16,2017.

[26] R P Narmadha and G Arulvadivu, "Detection and Measurement of Paddy Leaf Disease Symptoms using Image Processing", *IEEE International Conference on Computer Communication and Informatics*, pp. 1-4, 2017.

[27] V Gupta, N Sengar, M Dutta, C Travieso and J Alonso, "Automated Segmentation of Powdery Mildew disease from Cherry Leaves using Image Processing", *IEEE International Conference and Workshop on Bioinspired Intelligence*, pp. 1-4, 2017.

[28] Vijai Singh and A.K. Misra, "Detection of plant leaf diseases using image segmentation and soft computing techniques", *Information Processing in Agriculture*, vol. 4, no. 1, pp. 41-49, 2017.

[29] Ahmed AboBakr, Lobna A. Said, Ahmed H. Madian, Ahmed S. Elwakil, Ahmed G. Radwan, "Experimental comparison of integer/fractional-order electrical models of plant", *AEU - International Journal of Electronics and Communications*, vol. 80, pp.1-9, 2017.

[30] S Abed and AEsmaeel, "A Novel Approach to Classify and Detect Bean Diseases based on Image Processing", *IEEE Symposium on Computer Applications & Industrial Electronics*, pp. 297-302, 2018.

[31] Arya M, Anjali K and D Unni, "Detection of unhealthy plant leaves Using image processing and genetic algorithm with Arduino", IEEE International Conference on Power, Signals, Control and Computation, pp. 1-5, 2018.

[32] Kumar, S. (2022). Strategic management of carbon footprint using carbon collectible non-fungible tokens

(NFTS) on blockchain. Academy of Strategic Management Journal, 21(S3), 1-10

[33] Kumar, S. (2021). Review of geothermal energy as an alternate energy source for Bitcoin mining. Journal of Economics and Economic Education Research, 23(1), 1-12

[34] Dr. Naveen Nandal, Dr.AarushiKataria, Dr. Meenakshi Dhingra. (2020). Measuring Innovation: Challenges and Best Practices. International Journal of Advanced Science and Technology, 29(5s), 1275 - 1285.

[35] Nandal, N. Impact of product innovation on the financial performance of the selected organizations: A study in indian context. Psychol. Educ. J. 2021, 58, 5152–5163.

[36] S Hossain, R Mou, M Hasan, S Chakraborty and A Razzak, "Recognition and Detection of Tea Leaf's Diseases Using Support Vector Machine" *IEEE International Colloquium on Signal Processing & Its Applications*, pp. 150-154, 2018.

[37] S. Nema and A. Dixit, "Wheat Leaf Detection and Prevention Using Support Vector Machine," *International Conference on Circuits and Systems in Digital Enterprise Technology*, pp. 1-5, 2018.

[38] Vidyashree, Sunil S. Harakannanavar, Veena I. Purnikmath and Dattaprasad Torse, "Detection of Leaf Disease Using Hybrid Feature Extraction Techniques and CNN Classifier", Springer *Computing*, pp. 1213-1220, 2019.

[39] Pushpa, Shree Hari and Adarsh Ashok, "Diseased Leaf Segmentation from Complex Background Using Indices Based Histogram," *IEEE International Conference on Communication and Electronics Systems*, pp. 1502-1507, 2021.

[40] Mohammed Khalid Kaleem, Nitin Purohit, KassahunAzezew and SmegnewAsemie,"A Modern Approach for Detection of Leaf Diseases Using Image Processing and ML Based SVM Classifier", *Turkish Journal of Computer and Mathematics Education*, vol.12, no.13, pp. 3340-3347, 2021.

[41] Thanjai Vadivel and R. Suguna,"Automatic recognition of tomato leaf disease using fast enhanced learning with image processing", *Taylor & Francis, Acta AgriculturaeScandinavica, Section B — Soil & Plant Science,* vol. 71, no. 1, pp. 1-13, 2021.