University of Sindh Journal of Information and Communication Technology
(USJICT)
Volume 4, Issue 4, December 2020

ISSN-E: 2523-1235, ISSN-P: 2521-5582
Website: http://sujo.usindh.edu.pk/index.php/USJICT/

Citrus Leaf Disease Detection using Joint Scale Local Binary Pattern

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Abstract: Plant diseases are known from early times of cultivation and is also considered as one of the major factors affecting crops growth and quantity. Such losses from plant diseases can have a substantial economic impact, causing a reduction in income of farmers and higher prices for consumers. Today's agriculture demands regular use of high-tech technologies such as robots, moisture sensors, aerial surveillance and images processing. These technological shifts allow farmer to be more profitable and more environmentally friendly. This paper investigates and present Joint Scale Local Binary Pattern (JS-LBP) algorithm for detection of plant leaf disease based on image segmentation and texture analysis. The proposed method consists of two main phases, identification of disease lesion spot on citrus leaves and its classification. Leave images are pre-processed using top-hat filtering and two median filters, later these images are fed into the JS-LBP descriptor for feature extraction. Experiment shows that proposed algorithm attains 98.6% accuracy rate. Confusion matrix and ROC curve for different citrus diseases are also presented.

Keywords: Joint Scale Local Binary Pattern (JLBP); Support Vector Machine (SVM); K-Nearest Neighbor (KNN);

I. INTRODUCTION

As agriculture is the most critical driving force for the country's economy and it mostly depends upon the quality of agriculture products, while the quality depends upon other environmental factors such as weather. In today's agricultural world technologies such as mechanical devices, moisture sensors, aerial surveillance and other images processing procedures are used. These technological shifts allow farmer to be more profitable and more environmentally friendly. In less- developed countries crops losses from plant diseases may also result in hunger and starvation because of limited access to disease-control methods. Being an agricultural country, Pakistan's economy heavily depends upon production of citrus. According to Agriculture Marketing Information Service (AMIS), Directorate ofAgriculture Punjab, Lahore [1] in 2018, Pakistan produces 2.4 Million Metric Ton (MMT) of citrus. The province wise yearly production of citrus is listed in Figure 1The delayed or inadequate diagnosis of the citrus disease affects the growth and production of the plant [2]. In this study machine learning and image processing-based techniques are implemented to cater citrus plant leaf disease.

This paper is structured as, section 2 describes the taxonomy of citrus leaves disease. The literature review is presented in Section 3. Preprocessing and Proposed methodology is explained in Section 4 where section 5 elaborates the training strategy and classification procedure. Experimental results are presented in section 6, and section 7 illustrates the conclusion.

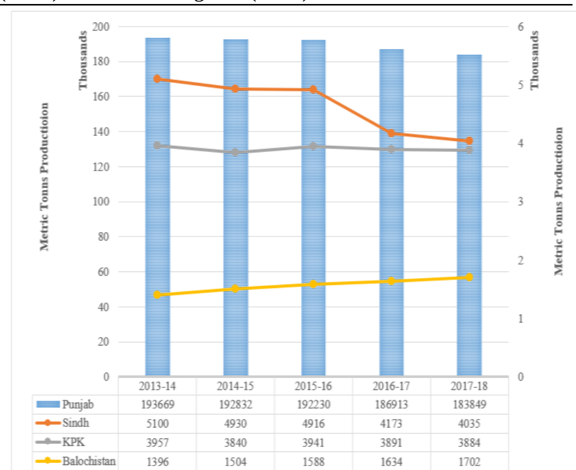


Figure 1.Yearly Citrus Productions

II. TAXONOMY CITRUS DISEASE

As citrus is the major source of vitamin C but its diseases badly affect the quality of citrus fruits and they are primarily responsible for the reduction in the production. A brief description of some of the citrus diseases like canker, blackspot, anthracnose and greening is discussed below.

A. Citrus Canker

Fungi and bacteria are the major cause of citrus canker and this disease spreads from one leaf to another. This infection creates diseases on the fruit, leaves, and stems of citrus plants including grapefruit, lime, and oranges[3]. To control this disease copper fungicides are used.

B. Black Spot

Guignardia citricarpa is the major cause of Blackspot and it lowers the quality and quantity of fruits. Almost all citrus plant varieties are affected by this infection, but it greatly affects trees and fruits causing lesions on them[4].The blackspot lesion is dark brown in color having diameter of 0.12mm to 0.4mm.

C. Anthracnose

Colletotrichum gloeosporioides is the major cause of anthracnose and its major symptoms are found on the leaf having circular area, light tan in color with a prominent purple margin. The lesion spots are 1.5mm or greater in diameter, and Azoxystrobin or Chlorothalonil is used to control and to prevent the disease[5].

D. Citrus Greening

Bacteria pathogen is the major cause of Citrus Greening and is difficult to control the affected plants and to reproduce it. Major symptoms include the yellowing of veins and nearby tissues, blotchy leaves, bitter taste fruit, dieback twigs and curved central core inside fruit. years[6]. Through proper sanitation and antibacterial implications, this disease can be controlled.

III. RELATED WORK

Different agricultural application techniques have been attempted by various researchers in the field of image processing and pattern recognition. Research scholars proposed some of the image processing techniques to improve the quality and quantity of the agricultural products. Image processing, image enhancement, CLAHE and feature extraction are the major steps used for the citrus canker detection. At first the sample leaf images are segmented into multiple parts. Then contrast limited adaptive histogram equalization and k-mean clustering is used to improve the contrast level of affected leaf image. The results show an effective accuracy in detecting canker disease from the affected leaves [7].

Goswami describe survey is being completed on the detection of leaf diseases which has used different techniques. To detect plant disease in initially stage are used color conversion, canny and Sobel edge detectors. Otsu and K-means techniques are used for some segmentation method. After extraction of feature occurrence classification techniques are used to classified plant images. To improve the disease images accuracy and processing time through using changing segmentation, feature extraction and classification technique [8].

Researchers used a methodology for early and accurate plant leaf disease detection. They worked on artificial neural network (ANN) and various image processing techniques for this purpose. Authors used ANN classifier that classify various plant disease using combination of feature, texture and color of the image [9]. C. H. W. Shanwen Zhanga reviewed different methods for leaf disease segmentation using image processing techniques. Several methodologies have been used to detect and classify plant pathologies over the years with different efficacy and ease of use. Segmentation and recognition strategy are used concerning plant pathologies [10]. It is Internet of Things (IOT) application for both segmenting and identification suggested on Super-pixel and K-means cluster methodology along with pyramidal structure of various histograms of orientation.

Apple Marssonnia Blotch (AMB) based research; Hyperspectral Imagery was used for detecting various stages of AMB. Without supervision, feature selection method called Orthogonal subspace projection (OSP) was employed for the selection of feature and redundant reducing one after the other. The size of spectral bands was ten out of six and the overall accuracy of was ten out of 71.3% was investigated [11]. Another research was based on classifying diseased and healthy apple. Initially, extraction of textures, (HOG) Histogram of orientation Law’s Texture energy (LTE), Gray-level Co-occurrence Matrix (GLCM) along with features Tamura. Various classifiers were deployed including KNN, SVM, LD. The accuracy factor of SVM was 98.1% [12].

Cost effectiveness is also a concern for third world countries where expensive machines cannot be used, and agriculture is the main source of income. In India SURF pattern imaging is provided to farmers with database of images of diseased textures in the android system which can be matched with a simple picture taken with a smart phone [13].

SVM and KNN technique was used in detection strawberry powdery mildew (PM) using image textures. The accuracy of the SVM procedure was turned out to be 91.86% which is very remarkable [14]. Leaf spot is a very deadly disease of sugar beet causing 10 to 15% loss in the production. In order to prevent the disease from disastrous spread and reduction in yield ,it is necessary to timely detect the symptoms and treating the disease. In this research, image processing and machine learning techniques are combined, and deep learning algorithms are used for earliest possible detection of symptoms. The results have shown increased efficiency than the previous studies in this regard. In the following study, the parameters of CNN model were changed to propose an updated faster R-CNN architecture for detecting leaf spot disease automatically. Total 155 images were used for testing and training the proposed algorithm and an accuracy of 95.48% was achieved. It is claimed that the proposed technique gives better outcomes within less time thus minimizing the time period of disease detection [15].

Tea leaf disease is severe one of plant effecting the tea leaves mainly, thus reducing the tea production badly. In the proposed study, a new method called low shot learning method is proposed to detect and prevent the disease timely. In this method features like color and texture are extracted through image processing methods, segmentation technique enhanced the disease spot area and SVM used for classification. The segmented images become input and through conditional deep convolutional generative adversarial networks (C-DCGAN) for data augmentation new training samples will be developed. Those are also used for training VGG16 deep learning model for the tea leaf's diseases detection. In the proposed study, the VGG16 deep learning model is claimed to detect disease spots effectively with accuracy of 90%. This accuracy level are much higher than previous low shot learning methods [16].

The work of Dae Gwan Kim is focused on the diseases of C itrus peel and the researchers aimed to detect the disease for the color texture features. The color images are initially carried out with the obtained citrus samples. Color images convert the RBG format into HIS format by spatial gray dependency matrices. The choice of ROI and transformation of color space is performed to determine the values of hue and saturation geometrically. Through simplifying the texture characteristics, the burden i s reduced, and the quality of classification methods was improved [17].

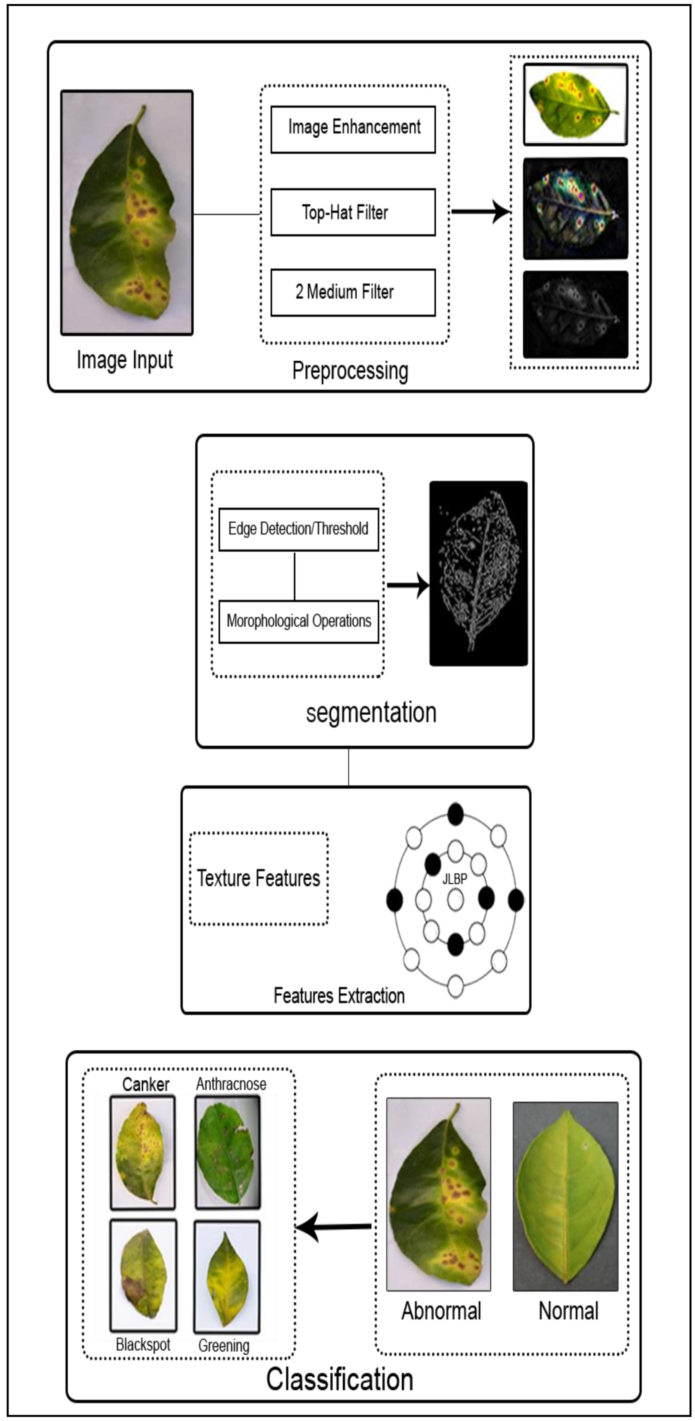


Figure 2. Architecture of Proposed Algorithm

IV. PROPOSED METHDOLOGY

Image processing play a important role in agriculture because of high accuracy of widely used observation of crop disease. This paper mainly focuses on the combination of four key measures (a) image enhancement and remove noise (b) identification of diseased region area using morphological operation, (c) Apply the texture features using Joint Scale Local Binary Pattern (JLBP) for extraction of useful information contained by the image (d) Classification is the final step, in which Support Vector Machine (SVM), K-Nearest Neighbor (KNN) classification learner are used to classify the image. The detail of each process is represented in Fig 2.

A. Image Acquisition

The primary step of citrus disease detection is image acquisition, in which we take images from different datasets (Repositório Digi-pathos and Data in brief) [22] [23]. The inputs are in RGB format, supports JPEG, PNG and TIFF. The images are resized to 256x256 pixels with a 72 PPI resolution and then different image processing techniques are applied.

B. Preprocessing

Preprocessing technique are improving to get enhance the visual quality of input images. The Input images have serval problem like noisy background, poor contrast effects images and illumination which can affect the segmentation [18]. Different preprocessing techniques are applied like Top-Hat filter, 2-D median filter are applied for images enhancement and Sobel operation edge detection are used for segmentation [19][20]. Sobel Operator calculating the gradient of image intensity at each pixel within the images. The flow diagram of Preprocessing and segmentation technique is show in Figure 3.

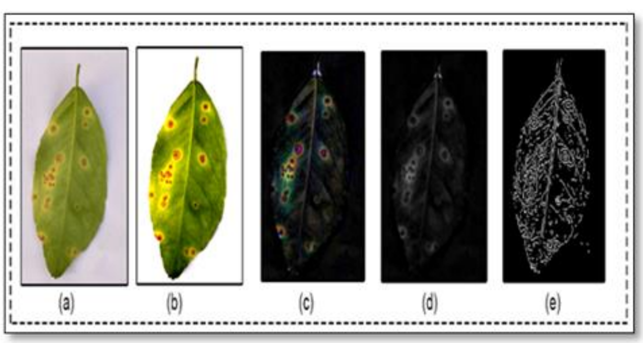


Figure 3. Image enhancement and Segmentation result a) Original Image, (b) Image Enhancement, (c) Top-hat filtering (d) 2-Mediam filter, (e) Edge detection.

C. Feature Extraction compute using Joint Scale Local Binary Pattern methodolgy

JLBP method is used for feature extraction. In which each object of an images has their own shape, color, size and texture, so their feature extracted the object is classified into their appropriate class. The proposed algorithm technique is used for citrus disease detection are based on join scale local binary pattern. In this study, Joint Scale LBP is used for multitier solution analysis. In it features are extracted by shifting the sampling constraints and then histograms are combined for multi-scale application [21].

Firstly, multiple scales are fused together using some arithmetic operation, then LBP code is obtained from integration of local patches. To demonstrate this, let's say R1 and R2 are two different scales and K is number of sampling points. The Computation way of JLBP are shown in Figure 4. The new topology structures $K, R1, R2$ The proposed JLBP (1) equation is:

$$JLBP_{K,R1,R2} = \sum_{i=0}^{K-1} s(p_i, R_1 + p_i R_2 - 2 \times p_c) \times 2^i \quad (1)$$

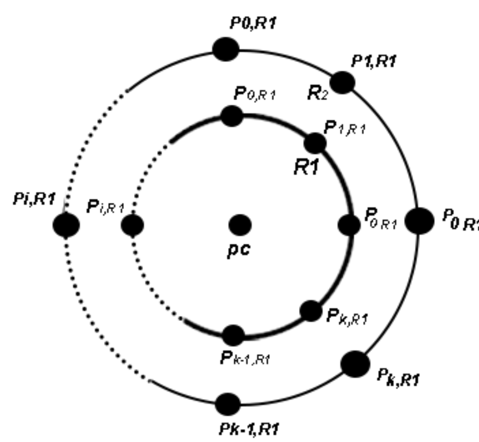


Figure 4. Principle of JLBP

Gray value of sampling points is $p_i R_l$. Now scales are joined through simple addition for JLBP, then JLBP code is obtained the same way as LBP is computed. The topology structure for JLBP can be extended to

$K, R1, R2, ...R_L$ where L is total number of multiple scales. Now the general JLBP equation (2) becomes.

$$JLBP_{K,R1,R2,....R_L} = \left(\sum_{l=1}^{L} p_i R_l - L \times p_c \right) \times 2^i \quad (2)$$

D. Classification

This phase explains the classification algorithms used in machine learning to classify diseases in plant leaves. Accuracy is depending on the number of samples taken and varies according to algorithms used in the classification. In citrus diseases the proposed method performed classification are focused on different technique and result are evaluate on SVM, KNN.

V. TRAINING STRATEGY

For training and testing purposes we have 655 images of citrus disease, and the image details are shown in TABLE I. Two different datasets are collected from the plant disease database available on [22] [23]. The images divided into 4 categories i-e citrus canker, citrus Blackspot, Citrus greening, Anthracnose and healthy and they are taken for the experiment. Through extensive experiments the performance is tested on selected dataset. Total 170 images of the leaf are affected by Canker disease, 100 images are blackspot, 138 are the category of greening disease and anthracnose has 57 disease spot images. Experiment are performed on different datasets and the results are computed in terms of accuracy.

VI. RESULTS

The results are assessed by the performance of algorithm and dataset of disease. Binary and Multi-level classification, the images of various disease are classified separately (i-e citrus canker, citrus Blackspot, Citrus Greening, Anthracnose and Healthy images respectively). The dataset is collected in the form of images that contain 72 DPI resolutions and they are resized into 255*255. The dataset is evaluated by healthy images and the result are computed. The Algorithm performance is evaluated on SVM, KNN as Shown in TABLE II and III. Algorithm Performance and accuracy are examining through various performance measures for example accuracy, Precision, Recall and F-1 Score. The selected features are fed to SVM and obtain classification rates of these four categories (canker disease, Blackspot disease, Anthracnose and Greening) are 99.2%, 99.3%, 98.5% and 97.6% respectively The average maximum result are obtained of 98.6% on SVM classifier. TABLE III and Figure 5 represents the comparsion of proposed techniques with other state of art methods and it show the authenticity of the proposed method. While in the comparison table the plant diseases (canker, blackspot, greening and anthracnose) and their detection accuracies based on SVM are compared with the accuracies of eight different reputed papers. And then through widespread experimentation the final overall accuracy obtained of our work is greater than the accuracies of previous techniques. Finally, the Figure 6 illustrates confusion matrix and ROC curve diagrams of different citrus diseases, respectively.

TABLE I. DATA SET DETAILS

Disease	Number of Images
Canker	170
Blackspot	100
Greening	138
Anthracnose	57
Healthy	200
Total Images	**665**

TABLE II. PROPOSED TECHNIQUE BINARY RESULT

Disease	Total No Image	TPR		FPR		Precision		Recall		F1-Score		Accuracy	
		KNN	SVM	KNN	SVM	KNN	SVM	KNN	SVM	KNN	SVM	KNN	SVM
Healthy/ Unhealthy	300	0.980	0.987	0.019	0.012	0.99	0.99	0.97	0.98	0.97	0.98	98%	98.7%

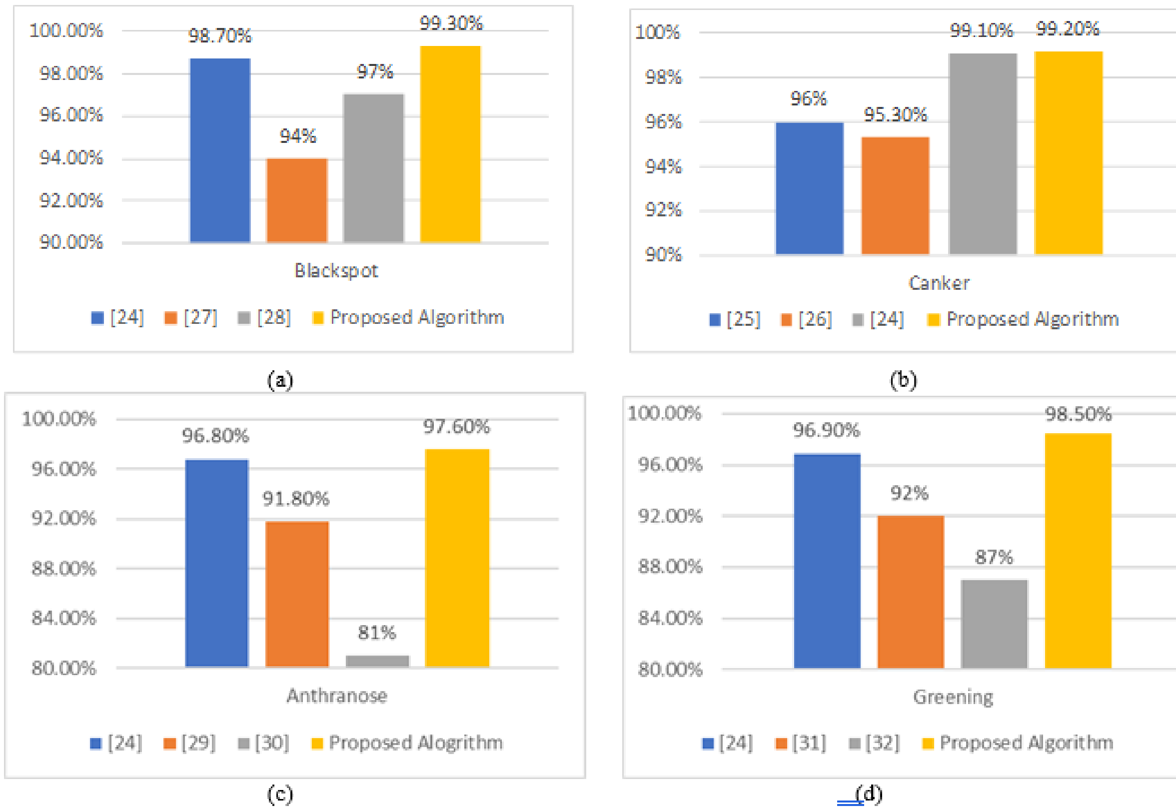


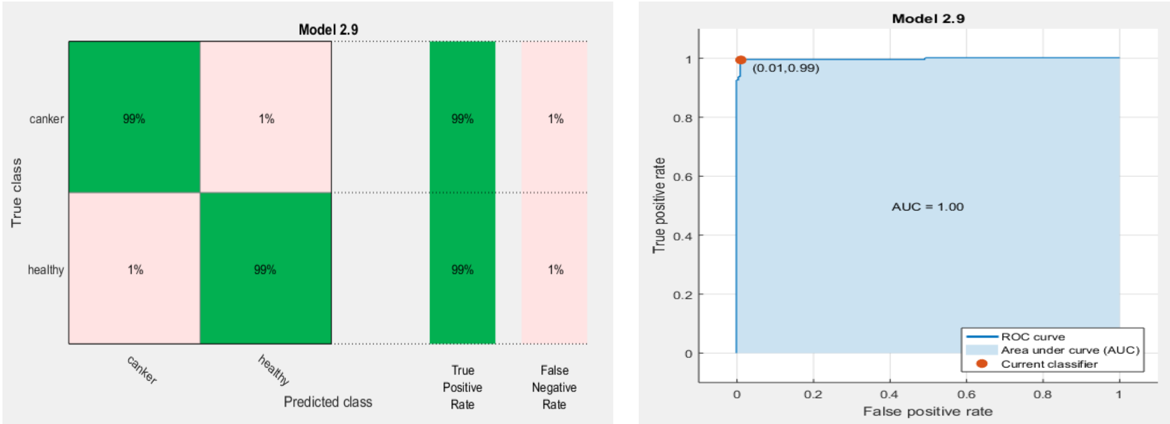
Figure 5. Comparison with other State of art Techniques (a) Blackspot, (b) Canker, (c) Anthracnose, (d) Greening

TABLE III. PROPOSED TECHNIQUE MULTI- RESULT

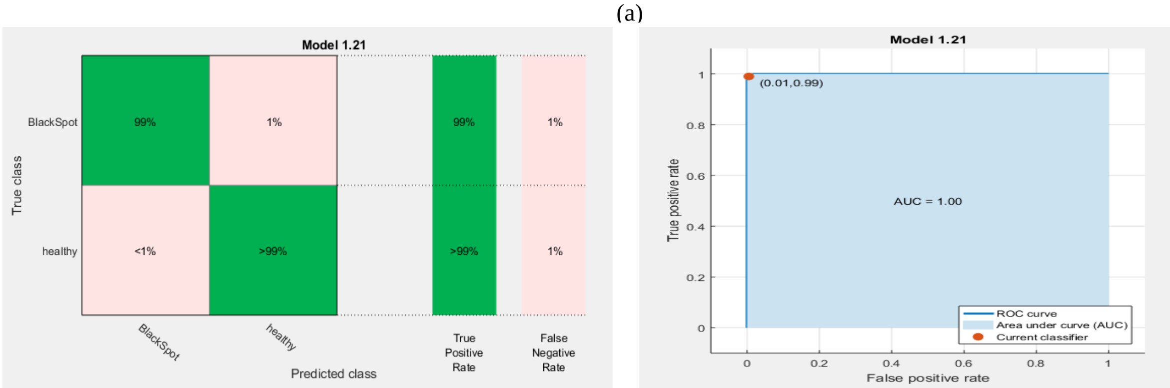
Sr. No	**Disease**	**Total no images**	**TPR**		**FNR**		**Precision**		**Recall**		**F1-Score**		**Accuracy %**	
			KNN	**SVM**	**KNN**	**SVM**	**KNN**	**SVM**	**KNN**	**SVM**	**KNN**	**SVM**	**KNN**	**SVM**
01	**Canker**	352	0.981	0.992	0.018	0.007	0.99	0.99	0.97	0.99	0.99	0.99	98.1	99.2
02	**BlackSpot**	300	0.980	0.993	0.019	0.006	0.97	0.98	0.97	0.98	0.97	0.98	98.0	99.3
03	**Greening**	338	0.962	0.985	0.037	0.014	0.98	0.97	0.95	0.98	0.96	0.97	96.2	98.5
04	**Anthracnos e**	126	0.968	0.976	0.031	0.023	0.91	0.95	0.97	0.97	0.93	0.95	96.8	97.6
Over all Accuracy													97.2	98.6

TABLE IV. COMPARISON OF ALGORITHM WITH OTHER PROPOSED TECHNIQUES

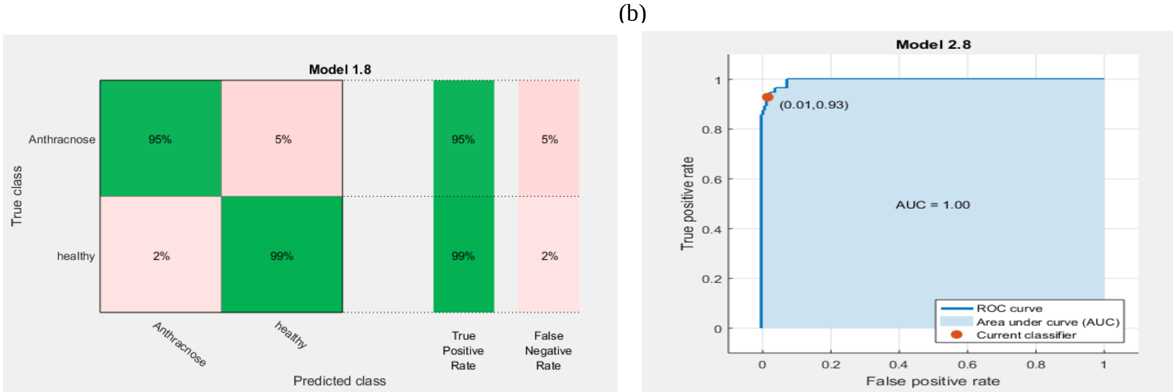
Sr. No	**Disease**	**[24]**	**[25]**	**[26]**	**[27]**	**[28]**	**[29]**	**[30]**	**[31]**	**[32]**	**Over Accuracy**
01	**Canker**	99.1%	95.3%	96%	--	--	--	--	--	--	**99.2%**
02	**BlackSpot**	98.7%	--		94%	97%	--	--	--	--	**99.3%**
03	**Greening**	96.8%	--		--	--	--	--	92%	87%	**98.5%**
04	**Anthracnose**	96.9%	--		--	--	91.8%	81%	--	--	**97.6%**
Average Accuracy		97%	95.3%	96%	94%	97%	91.8%	81%	92%	87%	**98.5%**



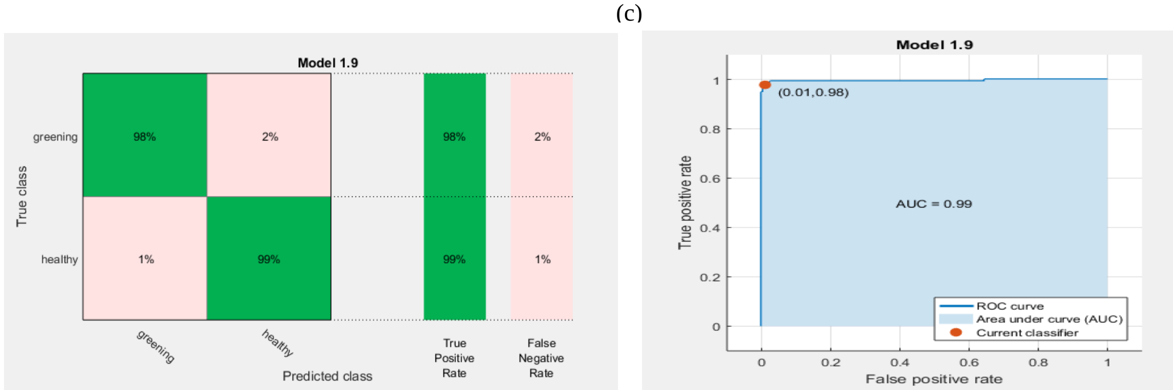
(a)



(b)



(c)



(d)

Figure 6. Confusion Matrix and Roc of (a) Canker, (b) Blackspot (c)Anthracnose (d) Greening

VII. Conclusion and Future Work

In this paper, distinctive machine learning and image processing approaches are used for detection and classification of citrus plant leaf diseases. The proposed technique is based on color, shape, and texture features of plant leaf. At first stage the leave images are pre-processed then Joint Scales LBP algorithm is used to extract the features. Then selected features are fed to SVM and KNN for classification of citrus disease. The performance is examined through various evaluation measure like Accuracy, F-1 Score, Precision and Recall. SVM outperforms KNN with 99.2%, 99.3%, 98.5% and 97.6% for canker, blackspot, anthracnose and greening respectively.

Acknowledgment

We are thankful to "Repositório Digi-pathos and Data in brief " to make publicly available research-oriented dataset.

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