Digital image processing application in Agriculture (Pest Detection) - Review paper ⋆

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Abstract

Image processing is an effective tool to analyze various fields and applications. Agriculture is one of the field in which digital image processing is being used. There are various parameters for measurement like canopy, yield, quality of crops etc. from farmers point of view. The aim of this research paper is to focus on the survey of application of image processing in agriculture sector such as fruits grading imaging techniques and weed detection. The result of such process proved to be more accurate and time saving as compared to earlier traditional methods. Digital image processing can improve decision making for vegetation measurement flower or fruits sorting irrigation etc. Every farmer wants to get maximum profit on less outlay. This can be achieved using digital imaging testing to ascertain the situation of crops. Because sometime advisor of agriculture sector may not available or affordable. Digital image processing can be useful to get advice from artificial advisor within proper time and at affordable cost since Digital Image Processing in an effective tool to analyze the parameter of crops grading. In this review paper we have gone through some existed paper. Wherein image processing techniques are applied to predict the disease present on leaves.

Keywords

CNN architecture (convolution neural n/w), SVM, K-Means, KNN, NN, RGB, Fuzzy logic, neural network, Otsu's algorithm, Deep Learning, LDA, PCA

1. Introduction

In recent year the growth rate of agricultural productivity has been declining, this happening because of climate change, increasing population growth, migration from rural to urban areas increase demand for biofuels. Climate change has been observed that there is close relationship between evolution of disease in crops, livestock and human being. Due to the change in weather pattern the pest and disease in crops start to grow to destroy the crops [1]. To get rid of pest and disease in crops farmer use pesticide, but chemical in pesticide decreasing the quality of food as well as food productivity. The United Nations organization of Food and Agriculture predicts that in order to provide food for the world's rapidly rising population, the planet will need to grow 70 % more food in 2050 than it did in 2009 [1]. The application image processing

ACI'22: Workshop on Advances in Computation Intelligence, its Concepts Applications at ISIC 2022, May 17-19, Savannah, United States

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Figure 1: Different pest damaging the crops [11]

technique and machine learning algorithm in disease and pest detection is an active field for research that shows immense potential to address the problem of early and accurate pest and disease detection in the crops. Various types of pests are shown in figure [1]. Plant diseases visibly show a variety of shapes, forms, colors [6]. Continuous monitoring is necessary for early pest and disease detection to prevent the pest spread in entire crops. Early identification of pest and disease in plant is a key point for crop management but this is time consuming, costly and inefficient using traditional techniques [3]. Moreover, lab equipment is too costly and lab test are destructive because lab test needs more sample to test the plants. So, getting rid of these problem automated image processing techniques for pest and disease detection in crops are used.

This paper consists of five segments. In first segment brief introduction about pest disease and detection is explained. In second segment we go through the various existing papers related to pest detection techniques. In third segment methodology then future work and in the last segment conclusion is summarize.

2. Some related work

In paper [4] in 2017 used image processing techniques to detect disease on cotton plant. A Support Vector Machine (SVM) separates morbid and healthy regions. Author used fuzzy classifier to predict the correct amount of fertilizer so that fewer pesticide Ought to be sprayed because more pesticide destroys the pest as well spoil the fertilizer of soil. Result of this paper was, it was proven KNN classifier obtain highest result compared to SVM classifier done upon two parameters accuracy and detection time.

In this paper of Mohammad et al. [7] in 2012, rice leaf was taken. Analysis of rice leaf for

detecting blast disease based on K-mean and KNN algorithms. KNN machine learning method was improved by K-means as an effective diagnostic method for disease by dividing k by n (initial instaces). This method is fast and less expensive comparable to other methods.
In this paper of Abirami Devaraj et al. [3] 2019 introduced FCM Clustering Technique for Segmentation. For clustering k-mean was used. For coaching and prediction K-Mean and SVM formula were used. The study dealt with Alternaria Alternata, Antracnose, Bacterial Blight and Cercospora Leaf Spot this automatic illness detection using image processing techniques in MATLAB. MATLAB is a language which gives high performance under technical computing. It involves loading an image, image pre-processing, image segmentation, feature extraction and classification. There was used automatic detection system using advanced technology. They show various result using affected.
Pest and disease detection can be done using Deep Learning also which is used by various authors in their experiments. Leaf disease and pest detection using deep learning- AI and deep learning have enabled the rapid evolution in the fields of computer vision and image analysis. This is all made possible by the emergence and progress of Convolutional Neural Networks (CNNs). A Convolutional Neural Network (CNN) is a deep learning algorithm that can recognize and classify features in images for computer vision. It is a multi-layer neural network designed to analyze visual inputs and perform tasks such as image classification, segmentation and object detection.
In paper of A. Devaraj et al. [3] Deep learning, the most recent breakthrough in computer vision, is promising for fine-grained illness severity classification, because the methodology avoids the effortful feature engineering and threshold-based segmentation. Exploitation the apple plant disease pictures within the Plant Village dataset that are additional annotated by botanists with four severity stages as ground truth, a continuous of deep convolution neural networks are trained to diagnose the extremity of the illness. It has proved that CNNs can be trained to detect microscopic features from high pixel value RGB colour image. It is automated and sped up the phototyping process so that disease severity progression could be monitor quickly and accurately.
For automation detection of disease in plant, Neural Network was used by authors M. Bommisetty et al. [10] in 2019. CNN was used for classification. There was done comparision between test image and trained model (CNN) if there was defect and disease then software was enabled to show the disease along with remedy. CNN has different layer layers that are Dense, Dropout, Activation, Flatten, Convolution2D, MaxPooling2D. After the model is trained. The author trained the software for different type of disease in plant like apple black spot, apple broad leaf spot, apple needle leaf spot, normal apple, bell paper normal, blueberry normal, cherry normal, cherry powder normal, corn blight, corn rust. The system was designed using python and gave accuracy of around 78%.
A. Fuentes [6] in 2017 proposed a robust deep-learning based detector for pest and disease detection. There was taken 5000 samples of images of tomato plants under different condition and scenario, that had 9 types of classes and annotated the images on the basis of disease present in the image. The faster R-CNN and VGG-16 detector were used to detect disease and pest on tomato plants. Faster R-CNN is an object recognition and its Region Proposal Network (RPN) to estimate the class and location of object proposals that may contain a target. candidate. The RPN was used to generate the object proposals, including their class and box coordinates. VGG

was used as feature extractor.
Image Processing through Machine Learning is the key role to classify different diseases in plants. Important image features are extracted from the image and is used as input. Image classification is one of the dependent factors on image processing technique [4]. Multi layered networks are the key point that uses its filters to automatically detect images from Datasets. CNNs can act as both image feature extraction and classification being the same architecture. Dataset. Sample of 10000 images is being used out of which some of them are healthy plants as well as among these leaves various type of disease was presented 1000 of each disease was taken [10]. There were include various type of disease like bacterial spot, early blight, late blight, target spot mosaic virus yellow leaf curl virus, leaf mold, leaf spot and spider mites. Proposed CNN model: they used CNN model this model. This module comprises of 3 convolution layers pursed by max polling layer The result of this was, the Dataset was trained with 80% training data while 20% of validation data. Various models were tested. The study of Convolutional Neural Network was helped to detect and classify plant diseases, the neural networks was trained to achieve 99% ability, with the ability of extracting important features of images this neural networks are step ahead to classify the disease of the plants.
U. Reddy et.al [17] developed an algorithm using CNN model to detect insect pest. There is used two types of datasets first one has nine and another has 24 types of pests such as Rice leaf roller, Rice leaf caterpillar, Paddy stem maggot, Asiatirice borer, Yellow rice borer , Rice gall midge, Rice Stemfly, Brown plant hopper White backed plant hopper, Small brown plant hopper, Rice water weevil and Rice leaf-hopper. Author used image augmentation techniques such as rotating, cropping and flipping, foreground extraction techniques and 9-fold cross validation techniques to improve the performance of system and achieved 90% and 91.5% classification accuracy rate for 24 and nine class of pest respectively.
L. Goyal et.al [19] proposed a novel classifier model using deep learning-based image analysis to recognise the type of disease. Author experimented to compare the performance of VGG16, RESNet50 and proposed model on the base of parameters such as accuracy, recall, precision and f1-score on the dataset having 12 thousand 224X2224 RGB images of wheat and achieved 98.62% and 97.88% training and testing accuracy respectively. The comparative analysis of techniques of several authors is summarized in table [1].

3. Methodology

Leaf disease and pest detection based on hand-crafted feature extraction Early works in automated disease recognition followed general workflow shown below using figure 2.

3.1. Image acquisition

The first step is to capture the affected crops from various type of disease. Researchers need proper setup of the wireless camera network. They should be operable in difficult climatic conditions such as direct sunlight and water projection resistance. Such a network is connected with sticky traps for insect pests capturing. In this step we can simply fetch the image from some source where we can detect the diseases. Without this phase, image processing is not

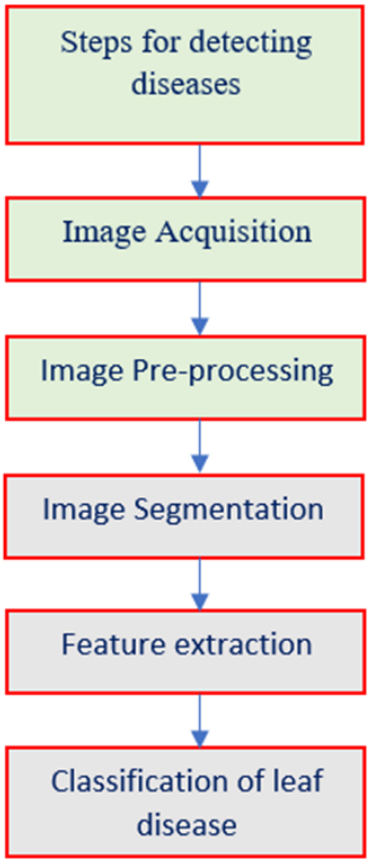

Figure 2: Different steps in image processing in pest detection

possible so first we acquired an image through webcam, mobile or any electronic device though a fixed distance and variable distances. Sensor playing key role to acquire image. Single sensor method can be used which is constructed of photodiode, which is constructed of silicon material and output voltage waveform is proportional to light. In Sensor strips is a geometry that is much more frequent than single sensor. In this arrangement electromagnetic spectrum are mounted perpendicular to the direction of flight which used in most flat bed scanner. In sensor array method individual sensor can be arranged in the form of a 2D array. Ultrasonic sensing and numerous electromagnetic devices are arranged in array format [12].

3.2. Image pre-processing

Image capture involves collection of photographic information using suitable camera. At this stage various operation performed that are image resizing, filtering colour space conversion and histogram equalisation. The size of images can be reduced using various algorithm like as nearest-neighbour interpolation, box sampling, fourier transform method deep convolution neural network. In paper [7], for image processing the image application was coded in MATLAB R2012a.The resolution of image was improved to do better diagnose the disease and to raise the

ability to diagnose the healthy surface [8]. Image pre-processing technique requires further processing the image for developing the image enhancement process to obtain high accuracy in the result. It starts with the appearance of each colour as RGB colour model primary spectral components. Such spectral components explain their respective intensities with respect to three components as Red, Green, and Blue (RGB). It has limitations as much time consumption by the process and need of large storage capacity. The large time consumption is due to the need for three different channel progressions in image processing. Grayscale image conversion can be done from RGB image using equation 1 [2].

$$I(x, y) = 0.2989 \times R + 0.5870 \times G + 0.1140 \times B \tag{1}$$

The filtering process remove the noise from the image appearance due to various lightening condition. The unwanted thing present in image is known as noise. Gausian filter is used to remove the existed noise from the image [9]. Filters provide usable and better throughput on using with digital image processing. It is important to know the correct methodology to apply various kind of noise removing techniques depend on particular image. Various existing works used a median filter for pixel observation [13]. The decision is made on the base of consecutive neighbour's pixel values that the value of its surrounding pixel values is selected the median of those values. Noise in the image can be either additive or multiplicative or impulse. Several types of noises are such as -1. Gaussian noise, 2. Rayleigh noise, 3. Gamma noise (Erlang noise), 4. exponential noise, 5. salt and peeper noise, 6. uniform noise, and 7. sinusoidal noise [13].
In Image processing, after removing noise from image we can convert image RGB (Red, Green, Blue) to HSI (hue, saturation, Intensity). Based on the colour, shape and texture we find the diseases in leaf. In machine learning, pattern recognition and image processing, feature extraction are process the image which initially build and derived attribute intended to be informative and non-redundant, facilitated to initial algorithm to determine the image. In image processing, algorithms are generally being used to digitalize the image or video stream [14].

3.3. Image segmentation

Segmentation of an image is a technique for conversion of digital picture into various segments and rendering of an image into segment for easier analysis. Using image segmentation is used for locating the objects and bounding line of that image. In segmentation, K-means cluster technique can be used for segmentation in which a minimum of one segment of cluster contain image with major space of unhealthy part [7]. The k-means cluster algorithmic rule is applied to classify the objects into K types of categories per set of features. The classification is completed by minimize the total sq. of distances among information entities and therefore the particular cluster. Image is regenerate from RGB Color space to L*a*b* Color space during which the L*a*b* area contains of a luminousness layer 'L*', chromaticity 'a*' and 'b*'[3]. Neural network is the strategy to segmentation of the photographs into leaf and background in to variety of size and color options are extracted from each the RGB and HSI representations of the image [4]. The segmentation of healthy and morbid regions is performed by suggests that of threshold. Rajneet Kaur et al tested two types of threshold that are Otsu's and native entropy. K-mean was used to segment the images and otsu method was used to automatic histogram of the threshold of images based on the shape or reduction of gray surface in binary image. According

to following written paper KNN is slow since it reviews all instances each time, it is vulnerable to dimensionality, it is sensitive to irrelevant and correlated attributes and a wrong choice of the distance or the value of k may degrade the performance. To overcome these limitation Mohammad et al. [7] instead of k, k/n was used where n was number of instances. Various segmentation techniques are following that can be used in pest detection on leaves.

3.3.1. Threshold Based Segmentation

Threshold value is used to divide pixel into two classes. Pixel that has value less than threshold value will be zero other wise it will be 1. Hence this technique will convert into binary map Ostu's and mean shift are thresholding-based segmentation techniques [4].

3.3.2. Edge Based Segmentation

There is used discontinuity as local feature to detect the edge and define the boundary of objects in image. It will help to detect the shape of object exist in image by using filters, such as Sobel horizontal and vertical filters and covolution. Canny, Laplacian and Gradients use this technique to classify the image [18].

3.3.3. Region-Based Segmentation

Region based segmentation algorithm detect immediate boundaries of seed pixel values and then classify on base of similarities of intensity and color. Region growing method and Region splitting and merging method are techniques of region base segmentation [18].

3.4. Clustering Based Segmentation

This segmentation is unsupervised machine learning algorithm. K-means comes under this segmentation. In this similar pixel come in similar cluster and there is not given label. It will segment the image into k segments [3][18].

3.5. Feature extraction

The input is given to the algorithm is huge and can lead to complex processing. The inputs given are compact of binding together so that it represents as set of features. If the features of the image are extracted wisely then that whatever feature set is available it gauges proper information from the input in order to perform relevant task [5]. In the paper [8], separation algorithm was used for profile extraction to remove the probable background from the received image. Image was spilited into three component red, black, green then rice plant was removed from background of image. LDA and PCA are common techniques to extract the feature. PCA-it is one of the most used linear dimensionally reduction technique. PCA is able to do this by maximizing variance and minimizing the reconstruct error by looking at pair wise distance. LDA-it is supervised learning dimensionality reduction technique and machine learning classifier. LDA main aim is to maximize the distance between the mean of each class and minimize the spreading within the class itself [15]. ICA(independent component analysis)- the purpose of

this is to correctly identify each of them such as deleting all the noises which is not necessary to us. In ICA we identify the different independent component in image registration [16].

3.6. Classification

Classification technique is used to coaching and testing of the leaf of the plants. In this phase we can find the exact diseases on the leaf. This phase is after the Image processing and feature extraction. After the diseases known we can analysis the behaviour of diseases we can distinguish which type diseases on the leaf. According to that we can exact analysis to determine avoid overhead water, better air circulation, or pesticides etc. Random forest classifier was used for classification by A. Devaraj et al. [3]. In 2017 R. Kaur et al. [4] used KNN classifier to classify sample images of plant. In k nearest neighbours. K could be a positive whole number, generally tiny. If k=1, then the sample is just assigned to the category of its nearest neighbour. process. SVM and k-means was also used by A. N. Rathod [5] for clustering and SVM the was used to classify the type of disease.
The k-means algorithm tries to split the data set which contains the information of particular data set into a fixed number of clusters (k). Primarily k. numbers of centroids are chosen [7]. A centroid is a data point which is situated at the centre of a cluster. This centroided is used to train the SVM. SVM is basically binary classifier which determines the hyper plane in dividing two classes [5]. The boundary is maximized between the hyper plane and the two classes. The samples that are nearest to the margin will be selected in determining the hyper plane are called as support vectors. Two different sets for train and test are generated using SVM. The steps for training and testing are same. The advantages of SVM are Accuracy prediction is high, it is robust. The complexity of computation of SVM doesn't depend on dimensions of the input space unlike NN. But SVM take large time in training and Learn function is difficult to understand in SVM [9]. Support vector machine comes under supervised learning model in the machine learning. SVM's are mainly used for classification and regression analysis. The SVM training algorithm creates a model that allots new examples into one category or into the other category, which makes it non-probabilistic binary linear classifier [5].

4. FUTURE SCOPE

The accuracy and speed can be improved by using google GPU for processing. This type of system can be installed on drone also for aerial surveillance. These techniques can be extended by superimposing and developing combined algorithms using Neural Networks to improve recognition rate for infected plant.

5. Conclusion

This paper presents the various techniques of image processing feature extraction and automatic pest detection on leaves. Various kind of techniques are described above by various author. The survey shows the efficient and existing methodology. Several methods are used by authors to obtain the knowledge of different background modeling for pest detection such as image filtering

for noise removing, image extraction and detection through scanning. This paper describes some author result in which some promising results to image enhanced methods and tool for automatic pest and disease detection. Entire world faces the challenges of crops production reduction by pest, disease, viruses, pathogens and weeds. Pest group attack on leaves of plant resulting is the loss rate and absolute losses. Under high productivity, condition leads high growth rate in tropic and subtropics region. However, such type of areas, the pest can be able to damage the crops in high rate due to favour climates condition. So farmer should also aware of such kind of techniques to obtain crop in high production rate. After combining the digital image processing techniques and CNN model accuracy is 99% that is remarkable performance. Future direction of this study can be carried out to develop more advance techniques in digital image processing in term of efficiently and accuracy. It can also be extended to design and efficient identification system for objects extraction.

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Table 1
Comparative analysis of the related work

Author	*Dataset*	*Methodology*	*Accuracy*	*Merits*	*Demerits*
Abirami et al. [3]	Various image infected from Alternaria Alternata, Antracnose, Bacterial Blight and Cercospora	FCM for segmentation, K-means for Clustering	-	System is user intractive.	Not focus on accuracy.
Rajneet et al. [4].	Images of leaves Infected from disease	NN, SVM, Fuzzy classifier, KNN For review	KNN classifier result give highest result compared to SVM classifier	Detection time is less	Yield accurate output for wrong image
Arti N. et al. [5]	Training texture feature data and testing feature data	NN and PNN for disease recognition and SVM For classification	96%	Detection rate is high	System is not robust
Alvaro et al. [6]	Images of tomato plant affected by gray mold ,canker ,l eaf mold , plague ,leaf miner , whitefly ,low Temperature	Deep convolutional neural network	80%	Model is robust	Accuracy is less
Mohammad et al. [7]	500 sample Canopy color images of rice leaf in RGB space used for testing	K-means for clustering and KNN algorithm for classification	94%	Cost effective and fast	Dataset is small
Xihai et al [8]	500 images taken from various villages plants and google websites having 8 types infected and healthy maize leaves	Deep convolutional neural network , SVM and PNN used for classification, GoogLeNet and cifar	98.8%	Training and recognition efficiency is improved	Less images in dataset are used.
Vishal et al. [9]	Images of various infected leaf	Machine learning for classification and CNN using python, Gaussian filter for image pre-processing	99%	Cost is less and accuracy is high	System is not general
Mihir et al. [10]	Sample of 10000 images having various type of disease and healthy leaves	CNN model comprising convolution layer using by max polling layer	99%	Accuracy is remarkable	Incur overfitting problem
L. Goyal et.al [19]	12,000 wheat images	VGGNet16 and ResNet 50	97.66%	Remarkable accuracy	Training time is high.