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A Review on different ML Techniques used for Disease Detection in Sugarcane Crop

Sharayu Mali*1, Sayali Nikam2, Adarsh Tambe3, Gausiya Sayyad4, Rajani Jadhav5

* 1,2,3,4 Student at Computer Engineering, SCTR's Pune Institute of Computer Technology, Pune, Maharashtra, India

5Assistant Professor, Computer Engineering, SCTR's Pune Institute of Computer Technology, Pune, Maharashtra, India

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ABSTRACT

Latest improvements in precision agriculture through machine learning, deep learning, remote sensing has helped to come up with different methods to detect crop diseases. One of the main reasons for yield loss of a crop is non detection of disease early in time. This paper reviews the various methods and techniques that can be used to detect diseases in sugarcane crop. Firstly, we provide a review on the different types of input data w.r.t imagery -RGB, multispectral and hyperspectral. Then we highlight the different techniques applied for disease detection-machine learning, deep learning, transfer learning and spectral information divergence. We also give an overview of the results achieved by using the different techniques.

Keywords: Disease Detection, Precision Agriculture, Machine Learning, Deep Learning

I. INTRODUCTION

Agriculture has been the prime and pre-eminent activity of every culture and civilization throughout the history of mankind since its invention and inception. It is not only an enormous aspect of the growing economy, but it's essential for us to survive. Agriculture is the most important sector that influences India's economic growth. India is the 2nd largest producer of sugarcane in the world. 54.55 lakh hectare of land is under sugarcane cultivation in India.[1] It impacts the livelihood of around 5 crore farmers while the average annual production is around 35.5 crore tons. India has also become a sugar surplus nation.[2]

Sugarcane cultivation and sugar factories play a very important role as growth centers in rural areas. Exploding population growth and increased per capita sugar consumption warrants increased sugar production with the available area. Application of latest technological developments for accurate forecasting of such important commercial crops can aid in future planning and policy making. Also, early detections for poor crop health or initial stages of diseases can go a long way in mitigating the undesirable effects like price rise and agrarian distress.

Yield loss in sugarcane is mainly caused due to non-detection of diseases early in time, miss of on-time harvesting of crops on optimum maturity age and post-harvest losses due to delayed crushing time. Around 20 to 30% of total sucrose loss is caused at various stages of raw material handling and sugar mill processing. Unpredictable growing environments, physiological conditions during the maturation period, variation in soil, soil moisture-holding capacity, degree of drying, etc. are some of the factors which affect the yield of crops.

Precision agriculture (PA) is an advanced science that is used for farming management based on observing, measuring, and responding to inter and intra-field variability in crops. It aims to improve crop yields and assisting management decisions using high technology sensor and analysis tools. PA includes use of technologies like Artificial Intelligence, Machine Learning, Internet-of-things, Remote Sensing etc. Satellite and UAV-based applications of remote sensing in precision agriculture generally use multispectral measurements to estimate high-spatial resolution information related to soil properties, plant health including detection of disease, and crop yields.

India, despite being the one of largest producers of sugarcane in the World, most diseases associated with crops are a major factor for reduction of sugarcane yield. More than 50 different types of diseases affecting sugarcane crop are found in India. Some of the diseases affecting sugarcane include red rot, smut, wilt, rust, Brown spot, ring spot, eye spot, yellow leaf, pokkah boeng and pineapple disease.

II. RELATED WORKS

The use of technologies like IoT, remote sensing, and cloud coupled with advanced processing, analytical and AI/ML based methods for disease detection has opened possibilities that will help in accurate and premature disease diagnosis on large scale farms with limited skilled human resource.

A. Different types of input data w.r.t imagery

Accurate disease detection can be achieved through remote sensing by taking visual sensos like cameras and performing analysis on them. Previous studies and research show that disease detection in sugarcane crop can be achieved with the use of normal RGB images, multispectral images, and hyperspectral images. Multispectral imagery and hyperspectral imagery provide remote sensing information using different bands. These can be collected by special sensors that can be mounted in UAVs i.e., unmanned ariel vehicles or through satellites. For example, satellites like Landsat-8 provide multispectral data and EO-1 with its "Hyperion" hyperspectral sensor provides hyperspectral data at 30 m resolution. [11] Study shows the potential of using vegetation indices derived from hyperspectral data to capture disease specific properties and use them to classify whether disease is present or not.

B. Different techniques applied for disease detection

A. Machine Learning:

Machine learning is a subset of artificial intelligence where programs learn to do a particular task from historical data without being explicitly programmed to do so. Traditional programs do not have the ability to understand images but using machine learning algorithms are well suited for tasks such as image classification, image segmentation and object detection.

[7] study proposes a solution for automatic detection of white leaf disease in sugarcane crops by using multispectral images from UAVs and supervised ML classifiers. Different ML algorithms - XGBoost, random forest, decision tree, and K-nearest neighbors, were implemented along with vegetation indices, and

five spectral bands to train model for detecting disease in the sugarcane field. It concludes that the XGBoost model provides the best performance with an accuracy of 94% and fastest execution time.

B. Deep Learning

Deep learning is a subset of machine learning based on artificial neural networks that are broadly modelled on the human nervous system with representational learning. Deep learning models are represented by multiple connected layers composed of neurons that can extract higher level features from the raw input.

[3] proposes a framework and two models that can automatically categorize aphid infestation on sugarcane leaves at leaf level using digital imagery using deep learning CNNs. The images were classified into sugarcane aphid densities at 6 infestation levels. The study evaluated the performance of four deep learning classification models: Inception v3, DenseNet 121, Resnet 50, and Xception of which Inception v3 and Xception provide accuracy of 86%.

[6] This study proposes a novel approach for accurate detection of diseases in sugarcane leaf images. This approach uses a combination of image pre-processing techniques like (CLAHE), optimal region segmentation and squeeze net based deep learning architecture for feature extraction. The expected features are then given as input to image classifier which is based on deep stacked auto-encoder model and uses a quantum behaved particle swarm optimization for hyper parameter tuning. The proposed method provides better performance than other models with accuracy, precision, recall and $F_{measure}$ of 97.28%, 97.50%, 97.50% and 97.50% respectively.

[12] paper proposes a customized hybrid deep learning model that is light weight for accurate and fast detection of sugarcane diseases. It consists of two main components – a CNN block that extracts shallow features, and another lightweight block for encoding the extracted features. The model was initially trained on Plant Village Dataset and then fine tuned on custom dataset containing 2095 images of six common sugarcane diseases and healthy sugarcane. The proposed model is lighter faster and slightly more accurate as compared to other deep learning models.

Application of deep learning methods in the field of computer vision for image classification, object detection, image segmentations, etc. have yielded much better performance in terms of accuracy as compared to traditional image processing and machine learning algorithms. CNNs have been used in many approaches for identifying diseases form images. The ability of deep learning models to automatically extract features and provide desired output gives them an edge over machine learning algorithms. However, these models require huge amount of data and processing power to train for providing accurate results in real time applications.

C. Transfer Learning:

Transfer learning enables storage of knowledge gained while solving one problem and reusing this knowledge to solve different but related problem. It gives a head start for deep learning models during training thus saving training time and provide better performance with less data. The concept of transfer learning can be used to fine tune models that have already been trained for one application/use case to adapt to another application/use case.

[4] In this study, the effects of epochs and batch size were evaluated with the performance of the different CNN models for sugarcane disease detection - AlexNet, ResNet 50, MobileNet V2, DenseNet 53, Inception V3 using accuracy, precision and recall values. The study tries to find out which best fitting Convolutional Neural Network model with

hyperparameter combination works best for the provided dataset. The dataset consists of 10 infected classes and an healthy class of images and was captured by DSLR camera manually. The experiment concludes that DarkNet 53 achieved best performance and performed best on the classification of insect pest damages. Its accuracy were 96% with epochs 25 and MBS of 16.

[5] evaluates the performance of different CNN models to predict the type of disease of sugarcane using the RGB images of sugarcane leaves. Three types of CNN Models were analysed in this paper to recognise diseases based on the leaves- LeNet, VGGNet and StridedNet. The dataset was composed of total 7 classes, 1 healthy crop class and 6 classes of diseases. These three models were analysed with different number of epochs and batches. It is observed that the StridedNet achieves the accuracy of 90.10%, LeNet model with accuracy of 93.65% and VGGNet with 95.40% accuracy. The study concludes that VGGNet model gives the highest accuracy with 40 epochs and StridedNet achieves the lowest.

D. Spectral Information Divergence

While using hyperspectral data, the spectral reflectance of diseased plants and healthy plants show different characteristics. Advanced processing techniques for calculating vegetation indices can be used for creating a library for storing spectral references of diseased and healthy crops which can be used for classification of pixels in hyperspectral images.[13]

[8] This study proposes the use of vegetation indices for detection of white leaf disease in multispectral images of sugarcane field. The difference percentage in vegetation indices that contain NIR and Red Edge bands provide highest difference between 44.05% to 45.10%, whereas the vegetation indices that contain only visible bands provide difference percentage between 14.96% to 26.04%. It shows the potential use of multispectral imaging as low-cost solution for detection of white leaf disease in sugarcane.

[9] This paper uses hyperspectral imagery for detection and mapping of sugarcane field area that have been affected by mosaic virus. The hyperspectral dataset was collected from an area of 111,178.75 m^2 with mapping done for healthy crop (54.1%), infected crop (mosaic disease-39.9%), weeds (3.3%), bare soil (1.3%) and unclassified class (1.4%). The classification was done using spectral information divergence to classify image pixels into healthy/infected sugarcane, weed or bare soil. The model provided accuracy of 92.5%.

C. Results published in previous studies

TABLE I

RESULTS OF DIFFERENT APPROACHES USED FOR SUGARCANE DISEASE DETECTION

Ref	Dataset Used	Algorithms/ Approach	Performance/ Accuracy
[6]	Custom dataset - 2 classes i.e., diseased, and non-diseased Each class contained 120 images.	QBPSO-DTL - Quantum Behaved Particle Swarm Optimization	QBPSO-DTL achieves 96.25% of accuracy with 1200 epochs
[7]	Custom dataset - 3 classes i.e., Healthy, Ealy symptom and severe symptoms	XGBoost, Random Forest Decision tree, K-nearest neighbors	XGB – 94% RF – 94% DT – 93% KNN – 94%
[3]	A dataset containing images of leaves having 6 classes and 5048 images	Inception v3, DenseNet 121, Resnet 50, Xception	Inception v3 - 86% DenseNet 121 - 85% Resnet 50 - 85% Xception -

			86%
[9]	Custom dataset - 4 classes i.e., Healthy, Mosaic, Weed, Bare soil.	Spectral information divergence	92.50%,
[4]	Custom dataset - 10 infected classes and 1 healthy class Total 3844 real time and 1643 controlled conditioned images	AlexNet, ResNet 50, MobileNet V2, Inception V3, DarkNet 53	DarkNet 53 - 96%
[5]	Custom dataset - 7 classes i.e., 6 diseases and 1 healthy class. Total 14,725 images.	LeNet, VGGNet and StridedNet	StridedNet - 90.10%, LeNet - 93.65%, VGGNet - 95.40%
[12]	Plant Village dataset Custom dataset - 7 classes i.e., 6 diseases and 1 healthy class. Total 2095 images	Shuffle-convolution-based lightweight Vision transformer	87.64%

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