



A thorough study of Deep Learning and Machine Learning methods for finding sugarcane foliage disorders

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KEYWORDS

Agriculture, Deep Learning, Sugarcane, Diseases, Environmental factors, Early Identification.

ABSTRACT

Our nation grows an enormous amount of sugarcane. Sugarcane is no exception to the rule that plants are susceptible to disease. One problem with the sugar industry is that small-scale farmers lose revenue when sugarcane diseases aren't identified and addressed in time to save the growing crops. A popular way for a farmer to discover and diagnose sugarcane illnesses is by visual inspection. Using this method on large farms becomes more laborious and time-consuming. The farmers and sugarcane business are both put at risk if it is not handled sooner. This inquiry was motivated by the ever-increasing types of ailments and the fact that farmers have limited abilities when it comes to diagnosing and identifying these diseases. A combination of Deep Learning (DL), Computer Vision (CV), and Machine Learning (ML) can solve this challenge. To boost agricultural output and efficiency, specialists have taken an interest in prompt disease identification and diagnosis. Losses may be avoided by employing ML and DL algorithms for early disease detection in sugarcane crops. The purpose of this research was to quickly and accurately extract diagnostic information from sugarcane using a variety of image processing and DL methods. Additionally, the difficulties and potential future directions of computational methods for evaluating sugarcane infestations are brought to light.

INTRODUCTION

ML and DL approaches are widely employed in all fields like agriculture, banking, finance, cyber security [1], Internet of Things (IoT), weather forecasting [2], and

recommendation systems. All four corners of our community are affected by the agricultural sector, making it the most vital sector for the financial stability of a nation. Sugarcane is one of India's most popular and

potentially lucrative crops. It has the potential to be both a cash crop and a main crop. To make brown sugar, which is needed to feed animals, tiny and medium-sized peasants gather sugarcane. Improvements in the production of sugarcane are necessary if the world's overall population is to remain constant. The yield of sugarcane is greatly affected by maladies and pests. This leads to huge financial losses for the nation and its agricultural producers. Consequently, to increase yield, it is necessary to use pest control measures and diagnose sugarcane illnesses promptly. The inaccurate detection of pesticide regulators is caused by the difficulty of visually detecting sugarcane leaf diseases. Rapid and accurate identification of sugarcane diseases is essential for improving yield and quality. Fast feature extraction from sugarcane leaves and early disease-type identification are two goals of image processing strategies. The increasing difficulties in farming environments caused by climate change, together with a lack of expertise and funding have piqued the attention of individuals making decisions, specialists, and farmers in ML as a potential solution. Multiple innovations, including sensors, unmanned aerial vehicles, GPS, and computations, use ML. So, it helps agricultural producers get their crops in the best possible shape, which boosts their output and ultimately their profits. In recent times, DL has found widespread use in the field of illness categorization. Damage to agricultural products, both in terms of quantity and quality, is mostly caused by infections. Nevertheless, there is a lack of ML-based technologies [3] that can classify diseases. In addition, there is a distinct scale at which disease epidemics impact lifestyle and nutritional well-being. As a result, both seasoned farmers and those who just started in the field need reliable methods of disease identification and categorization. Many diseases affect sugarcane crops. Fig.1 shows some common sugarcane leaf diseases. Fig.2. shows the taxonomy of sugarcane leaf diseases.

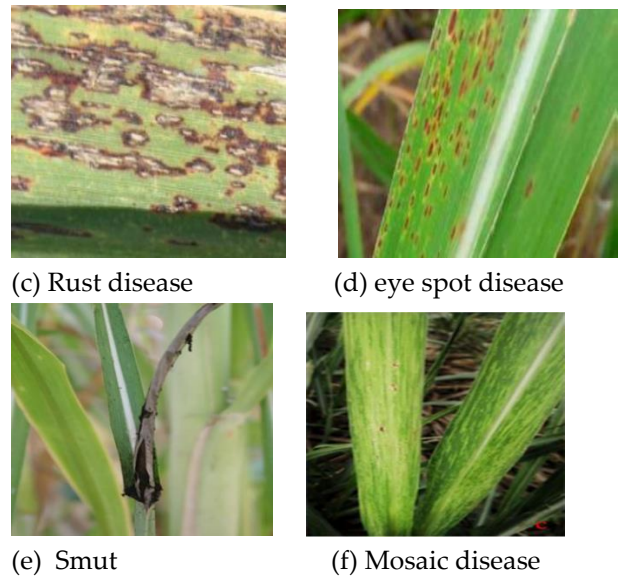


Fig. 1. Different images of Sugarcane leaf diseases

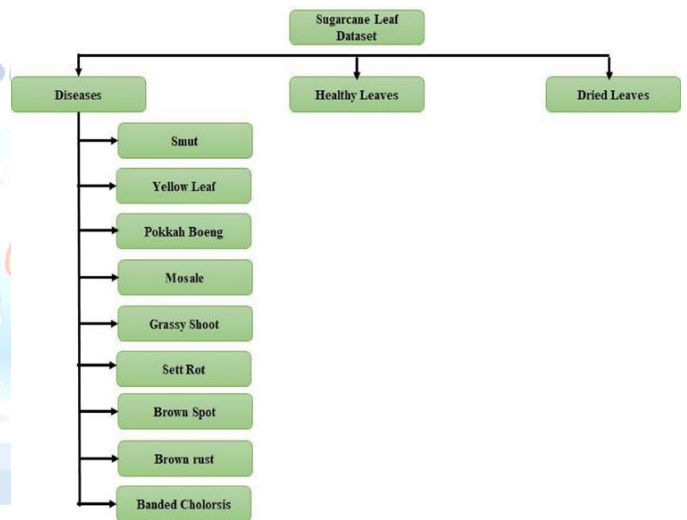


Fig. 2. Classification of sugarcane leaf diseases

It is common practice to categorize plant diseases as transmissible or non-transmissible. Infectious diseases are caused by infestations with bacteria, fungi, and viruses. Those that aren't contagious are caused by unfavorable situations in the environment. The majority of sugarcane illnesses are of the following types: yellow leaf disease, wilt, red stripe, smut, and red rot. Research has shown that ML may be useful for a variety of difficult agricultural activities, including crop classification, soil inspection, disease identification, rating, and crop wellness tracking. Recent developments in DL have focused on the requirement for prompt identification of diseases to safeguard crops promptly and pave the road for improved disease categorization. Early illness identification and categorization were addressed in many research using DL methods. DL



(a) Red rot (b) Sugarcane yellow leaf diseased

approaches are superior to typical ML strategies when it comes to detecting agricultural diseases utilizing datasets of different dimensions. To surpass ML models, DL procedures simplify the extraction of features, employ more data, optimize recognition, and utilize computational algorithms and systems. Problems using conventional disease prediction models in sugarcane crops include high data input costs, an absence of geographical data, or an inadequate dataset, among other things. The impetus for undertaking this research was the rapidly expanding categories of illnesses and the limited knowledge among agricultural producers when it comes to identifying and recognizing these diseases. This issue may be resolved with the help of ML by using CV algorithms that use DL. Table I shows the production of sugarcane in tons by ten different countries with India standing at number two in the production of sugarcane.

TABLE I. WORLDWIDE PRODUCTION OF SUGARCANE AT A GLANCE

S.No	Country	Production in tons
1	Brazil	7.7
2	India	3.5
3	China	1.15
4	Thailand	1
5	Pakistan	0.65 *
6	Mexico	0.6
7	Colombia	0.4
8	Indonesia	0.39
9	Philippines	0.32
10	Vietnam	0.2

RELATED WORKS

There have been a lot of recent studies on plant disease identification and classification, with many different methods suggested for diagnosing and detecting various crop diseases. Here an analysis of the literature on sugarcane disease categorization and detection using ML and DL methods is provided. The sugarcane leaf infection is located and identified by experts using a time-honored technique that is visible to the naked eye. It is common practice to require continuous monitoring to evaluate and confirm an accurate diagnosis. And yet, this method is impractical for large-scale farms. Seeking the counsel of a qualified professional in underdeveloped countries like India is both laborious and costly. Traditional sugarcane disease diagnosis, identification, and treatment are done manually. New automated technologies to handle these chores for

farmers will save time and decrease frustration. ML and DL advancements might solve this issue. Experts utilize the naked eye to identify sugarcane leaf disease. Continuous observation generally confirms and validates the diagnosis. Large farms cannot use this strategy. In underdeveloped nations like India, consulting an expert is expensive and time-consuming. Many techniques were employed by past researchers in identifying sugarcane leaf diseases including ML, DL, and ensemble approaches. A few of them are discussed below.

A. Machine Learning Approaches

Several researchers have utilized ML, a widely used approach, to classify and identify plant diseases. It is common practice to use algorithms that make use of legacy ML techniques. It is difficult to use this method in an online setting since it requires complicated mathematical equations. In some research, ML—a popular technology—is used to categorize and identify plant diseases. Common techniques utilized by conventional ML methods include Decision Trees (DTs), Random Decision Forest (RDF), Support Vector Machine (SVM) [4], and so on. More complex computations are required by this approach, which might be challenging for web-based software. Therefore, these strategies may only provide reasonable results when used.

B. Deep Learning Approaches

Due to its effectiveness and precision, DL has become popular in the agricultural sector, especially for the detection of plant diseases. When it comes to handling complex operations and finding patterns in images, CNNs are exceptional. It is possible to prevent loss and calamity by using ML technologies for early illness diagnosis in sugarcane crops. Consequently, DL is a fascinating approach to resolving this issue. When it comes to DL for plant disease detection, Convolution Neural Networks (CNN) have shown to be a popular approach. DL, in contrast to more CNN designs, makes use of Artificial Neural Network (ANN) architecture that, to process data, often has multiple layers. Expert analysis and decision-making have been revolutionized by the use of DL in plant disease detection. DL, which is based on ANN design, usually employs several additional layers to apply information, in contrast to traditional neural network topologies. DL has greatly improved the analytical and decision-making process for plant disease diagnosis.

C. Ensemble Approaches

A combination of ML and DL techniques is widely used nowadays to detect sugarcane leaf diseases. They include CNN+SVM, CNN+LSTM, DBN+SVM, DBN+Multi-class SVM, and CNN+RDF. Table II shows a few related works of ensemble approaches for sugarcane leaf disease detection.

TABLE II. A REVIEW OF SUGARCANE LEAF DISEASE DETECTION TECHNIQUES

study	Method	Dataset	Analysis/Merits	Demerits
[5]	Pretrained CNN model	Self-built dataset images were collected from sugarcane farms in the Philippines	It is possible to apply this approach to various types of leafy plants. When compared to different approaches, the InceptionV4 system had a 99.61 accuracy rate when it came to sugarcane leaf disease classification.	It is not indicated how large the dataset is. A dataset is too small. The experimental models may be fine-tuned to work at their best. There is a limited number of images in the dataset. The class imbalance problem in the dataset is not considered.
[6]	CNN	Public dataset from Kaggle with 1200 images only	97% accuracy rate. The model is reliable.	It takes a lot of time to train. The model should be tested in real-life settings. It is also possible to experiment with different learning rates and optimizers on the model. The dataset size

				is also small and data augmentation techniques can be employed to increase the size of the dataset.
[7]	CNN+SVM	Public dataset from Kaggle with 950 images only	98% accurate. There is a low mistake rate, and the severity estimate is typical.	Only one sugarcane leaf disease is studied i.e. smut. The study can be extended to other sugarcane leaf diseases also. The images of other sugarcane leaf diseases can be added to the dataset. The dataset size is also small and data augmentation techniques can be employed to increase the size of the dataset.
[8]	CNN+RF	public dataset	99.89 % accuracy. Training and detection rate is improved	It is possible to increase the detection efficiency by experimenting with various filters and layer depths. To make the dataset more generalizable, it may be expanded to include other crops with various illnesses in the future. It is possible to improve

				image identification by adding more convolutional layers.					considered for study i.e. red rot and red rust. More types of crop diseases, not only sugarcane ones, might be predicted using this model's extension. To avoid overfitting in the model, additional images might be obtained. Improved disease identification and accuracy might be achieved by investigating feature extraction and CV techniques. The dataset size is also small and data augmentation techniques can be employed to increase the size of the dataset. Fewer images in the dataset.
[9]	CNN+SVM	Self-built dataset with 2940 sugarcane leaf images	97.45% accuracy. Incredibly precise.	The dataset is rather tiny. The area of the leaf affected by disease is not studied. It is possible to enhance precision by using extraction methods based on fusion.					
[10]	CNN with Adam optimizer	Public dataset from Kaggle with 3000 images	96.75% accuracy	The proportion of leaves affected by disease is not studied. More types of crop diseases, not only sugarcane ones, might be predicted using this model's extension.					
[11]	CNN+SVM	Public dataset	Accuracy ranging from 88% to 92%	Accuracy can be improved by fine-tuning the model.					
[12]	CNN+SVM	Public dataset	Accuracy is 94.57%	Accuracy can be improved by hyper-parameter settings.					
[13]	CNN+SVM	Self-built dataset	87.39% accuracy	It takes a lot of time to train.					
[14]	CNN+SVM	Self-built dataset with 224 images only collected from the farms of Pune	98% accuracy.	Accuracy can be improved by using optimizers. Only two diseases were					
					[15]	VGG16+RMSProp Optimizer	customized dataset with 400 images	96.50% accuracy. Extensive data set. Inexpensive and quick to complete. Consistent and dependable. 400 images in	The severity of leaf disease is not studied. It is possible to test the models with varying learning rates, optimizers,

			the dataset were augmented to 6400 images.	and dataset sizes.
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ANALYSIS OF SUGARCANE LEAF DISEASE DETECTION METHODS

As a possible game-changer, after-plant disease prediction might provide farmers with the knowledge to anticipate disease outbreaks. It helps farmers recover their losses and enhances the quality of their products overall. Among the many problems that prevent agriculture from being economically successful are diseases caused by bacteria and fungi. The quality of sugarcane output, early disease detection, and prevention all need a reliable model, which researchers must develop. Computational approaches are being used more and more for the identification of sugarcane plant diseases. Agricultural and horticultural illnesses may be difficult to see with the human eye, hence several computational approaches for disease classification and identification have emerged in recent years. A large number of CV, ML, and DL models were identified and classified as sugarcane plant leaf illnesses in the literature study conducted between 2019 and 2024. The present review indicated, that CNN+SVM architectures resented in [7] [9] [11] [12] [13] and [14] produced promising results ranging from 87.39 % accuracy to 98% which is shown in Table III.

TABLE III. REVIEW ON CNN+SVM METHODS FOR SUGARCANE LEAF DISEASE DETECTION

Method	Accuracy (%)
CNN+SVM [13]	87.39
CNN+SVM [11]	92
CNN+SVM [12]	94.57
CNN+SVM [9]	97.45
CNN+SVM [7] [14]	98

Using computational techniques to analyze and diagnose photos of sugarcane and its leaves has revealed further obstacles, according to the study. The whole analysis of the present review concluded that most of the research on sugarcane leaf disease detection revolved around a single ensemble approach i.e CNN+SVM and its analysis is given in graphical representation in Fig.3. It is suggested to young researchers to use other powerful ensemble approaches like CNN+LSTM,

DBN+SVM, and DBN+MultiSVM for sugarcane leaf disease identification.

One way to improve overall performance is by using ensemble approaches. These methods include several CNN+SVM models, each trained with distinct initializations or subsets of data. By doing so, you may reduce variance and increase accuracy. To make sure the model works in real-life situations, regularization approaches like dropout may reduce the likelihood of overfitting. The accuracy and reliability of disease detection systems for sugarcane leaves may be greatly enhanced by methodically tuning CNN and SVM components while using sophisticated approaches in both. To further enhance performance, it is recommended to fine-tune the CNN+SVM models using a bigger and more varied dataset that is tailored to sugarcane diseases. This will help the network learn more deeper and complicated interpretations.

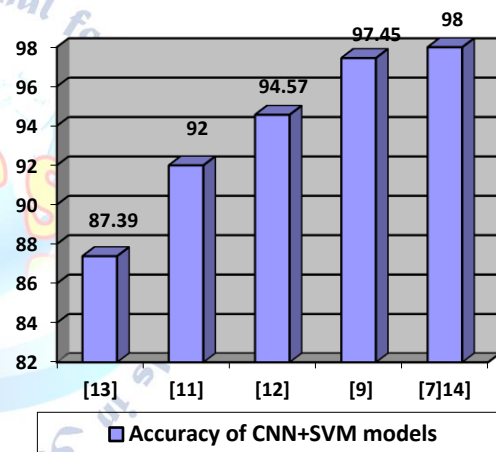


Fig. 3. An analysis of CNN+SVM-based approaches for sugarcane leaf disease detection: A Graphical interpretation

OPEN CHALLENGES

There are many open challenges for sugarcane leaf disease detection systems using ML and DL. A few of them are discussed below and the rest of the issues is given in Table IV.

- (1) For small-scale cultivators, the employment of complicated instruments such as electromagnetic radiation, infrared spectra, and plant genetics to increase the efficacy and precision of feature extraction is too expensive.
- (2) Access to extensive datasets including a wide range of sugarcane leaf diseases, from early stages to those caused by specific environmental factors.

- (3) Because environmental conditions may cause symptoms of sugarcane illnesses to vary widely, it is difficult to include all of these variances in training data.
- (4) Models trained using datasets that have an uneven distribution of sick and healthy specimens may fail to identify less common illnesses.
- (5) There has to be excellent efficacy and smooth interoperability for disease detection systems to be integrated with current precision agricultural technology.

TABLE IV. A FEW OPEN CHALLENGES OBSERVED FROM EXISTING WORKS

Attribute	Open Challenge
Lighting	The bulk of sugarcane leaf images seem darker in situations of non-uniform light. Irregular contrasts in the foliage and worse visual clarity make it hard to make out the image's characteristics.
Quality of Image	The photographs of sugarcane leaves were taken by researchers at random using a low-quality camera. As a result, it may not be sharp enough to identify the specific diseased regions you need.
Overlapping and uneven boundary shapes	Inconsistent sugarcane image mixtures and uneven boundary shapes make it harder to extract traits for disease diagnosis.
Background	Due to the inability of most methods to differentiate leaf pictures from the complex background, an accurate estimate of the Sugarcane leaf border was not possible.
Edge Detection	The edge identification technique does not specify which pixels from the tarnished sugarcane leaf pictures should be discarded due to distortion.
Image backdrop	Locating the sick leaf patch is next to impossible due to the low picture quality and the complicated image backdrop.
Misclassification	There are flaws in the classifier that cause it to incorrectly label healthy leaves as diseased. Thus, the current computing system is imprecise.

CONCLUSION

Agriculture is the most prevalent kind of production worldwide, and it has been greatly enhanced via many scientific breakthroughs that have contributed to better growth techniques throughout the years. Diseases infect agricultural goods, lowering crop quality and yields of fruits and vegetables. One of the most popular cultivars utilized in the sugar industry is sugarcane. Sugarcane has a lot of alkaline minerals that help prevent illnesses like cancer from spreading. These minerals include

calcium, magnesium, potassium, and iron. Illness observation and ineffective pest control techniques reduce sugarcane output. Due to inadequate disease control, farmers incur millions of dollars in costs to treat sugarcane plant diseases. That is why it is so important to use evolutionary computation techniques for sugarcane plant disease detection. The purpose of this study is to examine existing ML and DL methods for sugarcane analysis and to extract useful characteristics that may be used for disease detection and analytical decision support. The current state of computational approaches for sugarcane disease diagnosis is insufficient, hence the creation of an automated system is required. This study will help researchers create computer algorithms that can quickly and accurately diagnose sugarcane diseases, which would enable farmers to increase their sugarcane yield.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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