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MAIZE LEAF DISEASES PREDICTION USING MACHINE LEARNING:A LITERATURE SURVEY

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Abstract. Accurate and timely detection of crop leaf diseases is vital for ongoing agricultural productivity growth. In this paper, we give a thorough evaluation of recent research employing deep learning, machine learning, and image pro- cessing techniques for detecting maize leaf diseases. Deep learning (DL) methods are usually used in classification of plant diseases, especially those based on con- volutional neural networks (CNN), increasingly frequently. This article surveys the research publications that presented the various methodologies and evaluates them based on the dataset, number of images, number of classes, techniques used and the end outcomes. In terms of performance, modified DL techniques beat traditional ML techniques in detecting maize leaf disease.

Keywords: Deep Learning, Machine Learning, Convolution Neural Network.

1 Introduction

Maize (Zea mays L.), after rice and wheat, is the most significant cereal crop that is cultivated in a variety of environmental circumstances throughout the world [1]. India is ranked fourth among the 170 countries that grow maize, but seventh in terms of pro-duction. It contributes roughly 4.6% and 2.4% of the world's total acreage and produc- tion respectively [2].

The majority of India's maize-growing regions are plagued by several common dis- eases, including Maydis Leaf Blight (MLB)/Southern Corn Leaf Blight (SCLB), Tur- cicum Leaf Blight (TLB)/Northern Corn Leaf Blight (NCLB), and Banded Leaf and Sheath Blight (BLSB).

The diseases which we focused on are Blight and Common Rust, which are most pre- vent in India (https://iimr.icar.gov.in/?page_id=2136) and based on the literatures sur- vey done. Maydis leaf blight (or southern maize leaf blight) is prevalent in hot, humid, maize- growing areas.

1.1 Northern Corn Leaf Blight

Northern Corn Leaf Blight (NCLB), also known as Turcicum Leaf Blight (TLB), is the most serious and widespread disease infecting maize leaves worldwide, especially in India. The NCLB disease initially affects lower leaves in favorable environmental conditions before progressing up the plant. High humidity, low temperatures, and cloudy conditions are conducive to the development of disease on the host plant [16, 17]. Northern corn leaf blight (NCLB) is a fungal disease of maize or corn (note that in thesis corn or maize will be used interchangeably) and is caused by a fungus called Exserohilum turcicum (Jackson-Ziems 2016). The fungus is active and grows well in cold to moderate temperatures and high relative humidity. Studies indicate that NCLB is present in most of South Africa's maize-producing areas. The disease is also sporad- ically common in other moist maize-producing regions of the world.

There are ways to reduce the infection. These include:

- Crop rotation with a non host crop like legumes to reduce the disease se- verity of Turcicum leaf blight by providing the time for infected residue to break down and to prevent disease development in the subsequent corn cropby reducing the overwintering fungus.
- Destruction of crop debris.
- Use of resistant
- Chemical treatment for seeds. growing areas.

1.2 The Southern Corn Leaf Blight (SCLB) and Maydis Leaf Blight (MLB):

It is a fungal disease that the plant pathogen causes that affects maize. Known by many names, including Southern corn leaf blight (SCLB) or Maydis leaf blight (MLB), this fatal foliar disease of maize is caused by the fungus Cochliobolus heterostrophus (formerly known as Helminthosporium maydis. Tan to brown lesions is typical initial sign of SCLB, which often begins at the lower leaves and moves upward. The lesions may be shaped like a typical rectangle, and in the right circumstances, they may com- bine to cause significant harm. It grows in humid, warm environments around the world [18, 19]. It can significantly reduce yield and quality of grains if left uncontrolled.

- Destroy infected crop residue from the field
- Use of resistant/tolerant hybrids
- Foliar spray of Mancozeb @ 2.5 g/ L of water after about 15 days after sowing is effective and provide two more sprays at 10-day intervals or im-mediately after symptoms appearance.

1.3 Banded leaf and sheath blight:

One important maize pathogen is the basidiomycete fungus Rhizoctonia solani, which is mostly prevalent in China, South Asia, and South East Asia. It causes banded leaf and sheath blight (BLSB), a plant disease that is thought to be an emerging disease that causes anything from small losses to total crop elimination. Additionally, diseased leaves senesce or dry out and die more quickly, and young tillers may be lost. Consequently, the disease may significantly lower the leaf area of the canopy [20, 21].

Causal organism: Rhizoctonia solani

Stripping of lower leaves along with their sheath Use of resistant/tolerant hybrids
Foliar spray Azoxystrobin 18.2% + Difenconazole 11.4% w/w SC (Amistar Top 325 SC) 1ml/L of water at 50 DAS or immediately after symptoms appearance. If needed, repeat the spray at 15 days interval

1.4 Common Rust

The common rust is caused by the fungus Puccinia Sorghi. Late-onset infections have very little effect on yield. These are easily recognized and distinguished from other diseases because they create dark, reddish-brown pustules (uredinia) on both the upper and bottom surfaces of the corn leaves [19, 22, 23]. It flourishes in warm, humid con- ditions, typically during the mid-to-late growing season.
Methods to prevent include:

- Residue management through sanitation, tillage and crop rotation
- Ploughing down of crop debris may reduce early infection
- Performing Chemical Treatment like spraying of fungicide Dithane M-45 applications @ 2.5-4 g/L of water at first appearance of pustules. If disease is severe three sprays at 15 days interval are recommended

Keeping in mind the damage caused due to leaf diseases, we have designed a CNN based model for the detection of maize leaf.
The general aim of this study is to introduce CNN approaches into classifying vari- ous types of maize leaf diseases (GLS, CR and NCLB), and to predict the severities of CR and NCLB thereof. Therefore, the three specific objectives of this study are listed below:

i. To create and test a CNN model that can classify various types of maize leaf dis- eases.
ii. To set up and test a CNN model that can predict the severities of a maize leaf disease known as the maize CR. The model is to be a hybrid model because fuzzy logic rules are intended to be used with a CNN model.
iii. To build and test a CNN model that can predict the severities of a maize leaf disease known as the NCLB by analysing lesion colour and sporulation patterns.

2 Literature Review

A lot of study has been done with deep learning (DL) which is a branch of machine learning. Artificial Neural Networks form its basis. Numerous deep learning techniques exist. Nonetheless, Convolutional Neural Networks (CNNs) were the most often uti- lized. CNN has developed into a dependable DL system for detection, localization, seg- mentation, grouping, and classification. To increase computation times and perfor- mance metrics, numerous CNN architectures have been tested [8]–[11].

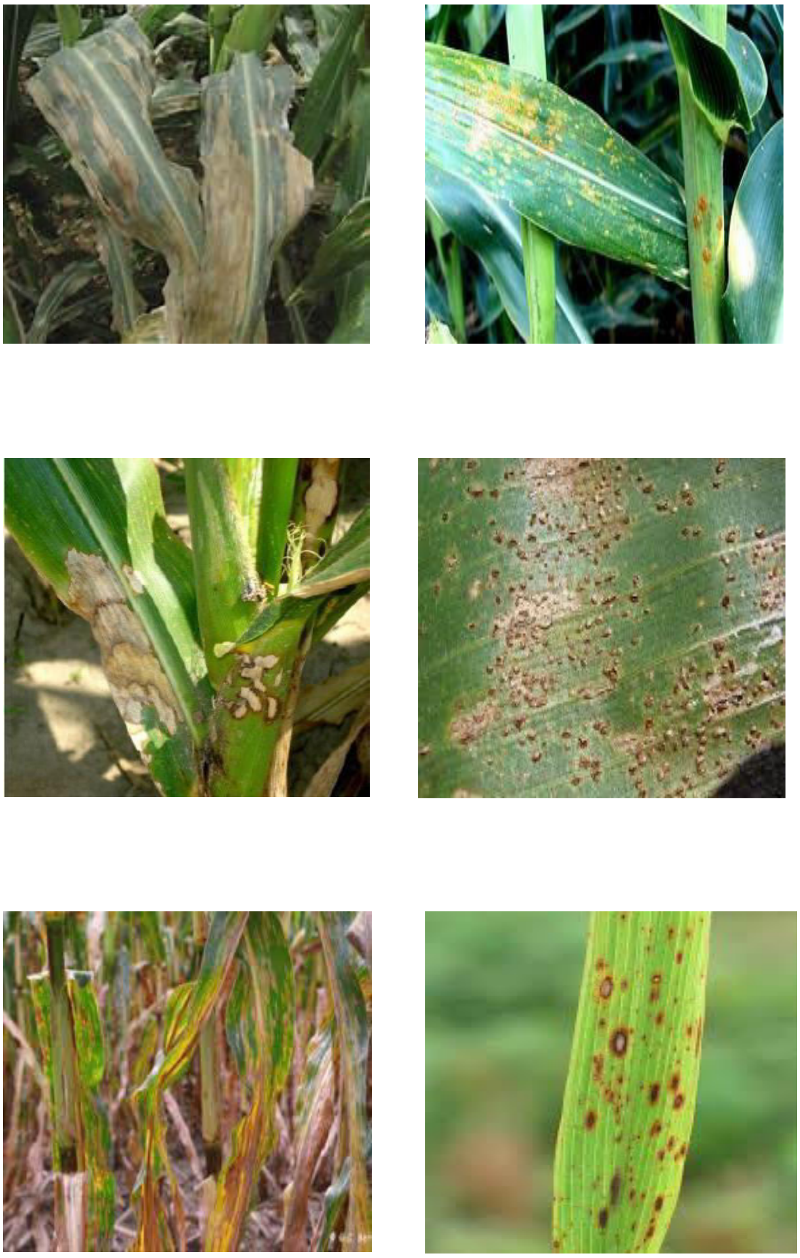
Several researchers have contributed to this field. Among them, the recent work in-cludes the work by M. Çakmak [12], who proposed the use of EfficientNet deep learn-ing model for the classification of leaf diseases in maize. The model was trained using the maize leaf disease dataset. 4188 images were used for the original dataset and 6176 images for the augmented dataset. The diseases studied were common rust, gray leaf spot, and leaf blight. The proposed model was then compared with ResNet50, Dense- Net121, VGG19 and Inception V3 models based on their accuracy, sensitivity, F1- Score and precision values. The EfficientNet B6 model achieved 98.10% accuracy on the original dataset, while on the augmented dataset, the EfficientNet B3 model achieved the highest accuracy of 99.66%.

Another research by Rai and Phuja [13] used a deep learning-based Attention U-Net model for exploring a real-time approach for segmentation and detection of NLB dis- eases. After image annotation, data augmentation was performed for increasing the model's effectiveness. The model's performance was evaluated on the test dataset after it was trained for a maximum of 50 epochs with Adam as an optimizer and an initial learning rate of 0.0001. According to the study, the Attention U-Net model performed better than the Res U-Net and Plain U-Net image segmentation techniques, yielding better results with respective Intersection over Union (IoU) values of 72.41%, 70.91%, and 51.95%. The suggested model obtains an average F1 score of 85.23% pixel-by- pixel.

One such work presented the use of deep convolutional neural networks for the iden-tification of diseases in maize plants [14]. The authors collected 4,988 photos of three different but common varieties of maize diseases: leaf-blight, common rust, and gray leaf spot. All of these images were input into 13 distinct pre-trained CNN models for testing and training, including Xception, Shufflenet, Resnet-18, Resnet-50, Resnet-101, Alexnet, Densenet201, Googlenet, InceptionresnetV2, InceptionV3, MobilenetV2, VGG-16, VGG-19, and Resnet-18. All the models' performances were noted in terms of MCC, Kappa, F1 Score, accuracy, specificity, and precision as well as False Positive Rate. Based on the comparison results, VGG-19 has the highest False Positive Rate (FPR) and the lowest accuracy among all the models for the mentioned diseases whereas Densenet201 has the highest accuracy overall.

Rashid et al. [15] developed a multi-model network fusing multi-contextual net- works, which is automatically exploited with the CNN strategies, with some variant forms. MMFNet with fused features performed considerably better than without fused feature methodology in terms of accuracy. An overall accuracy of 99.23% was obtained which was due to training on the combination of heterogeneous datasets.

Plant diseases are a major factor in the global decline in agricultural productivity. Disease symptoms have a detrimental effect on food plant growth and development, lowering yields and rendering agricultural products useless. The illnesses and symp- toms that impact the yield and caliber of the rice, wheat, maize, and soybean crops are unknown to farmers. Grain crops have been impacted by a number of illnesses, such as northern leaf blight, smut, common rust, brown spots, and gray leaf spot.



(a)(b)

(c)(d)

(e)(f)

Fig. 1. Various types of diseases reported in maize leaf. (a) northern corn leaf blight;
(b) southern corn leaf blight and maydis leaf blight; (c) banded leaf and sheath blight; (d) common rust; (e) gray leaf spot; (f) brown spot.

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3 Model Architecture

The stages of the maize leaf classification model architecture and disease detection in-clude picture capture, image pre-processing, segmentation, extraction of features and classification. These phases can be used for the identification and categorization of maize leaf diseases based on their visual symptoms [34].

3.1 Capturing images

This is the first step in recognizing and categorizing illnesses of crop leaves. The goal is to compile and get ready the image dataset that will be employed in the subsequent process. This is achieved by shooting images with mobile phone cameras, digital cam- eras, drones, and unmanned aerial vehicles (UAVs) in controlled or real-time environ-ments.

Table 1. Overview of ML and DL techniques used in Maize Leaf Disease Detection.

Diseases diagnosed	**Dataset**	**No. of im-ages**	**ML/DL Techniques used**	**Accuracy obtained**
The northern corn leaf blight, Gray leafspot, Common rust, Healthy leaf	Plant Village	400	Neuroph's CNN	99.9% [22]
Gray leaf spot, Cur-vularia leaf spot, Round spot, Dwarf mosaic, Northern leafBlight, Bown spot, Southern leaf Blight, Rust	Google and Plant Village.	500	GoogLeNet Cifar10	98.9% 98.8% [21]
Common rust, Gray leaf spot/Cercosporaleaf spot, Northern leaf blight Healthy	Plant Village	3823	CNN Model	98.78% [27]
The northern leaf blight, Zinc defi-ciency, Gray leaf spot, Round spot, Common rust,Fall armyworm, Healthy leaf	Google webpages and Plant Village	12227	DMS-Robust Alexnet	98.62% [26]
Optimal moisture, Mild drought, Moder-ate drought stress	Field	3461	Resnet152 & Resnet50	98.14% 95.95% [28]

Common rust, Gray leaf spot, Northern leaf blight, Healthy crop	Internet	12,332	Dense CNN architecture	98.06% [17]
Blight, Common rust,Sheath Blight & Healthy leaf	Vocational and Technical Col- lege of Inner Mongolia Ag- ricultural Uni- versity,China	4428	ResNet50	97.41% [29]
Blight, Gray leaf spot, Healthy leaf & Common rust	Plant village data set and In-ternet	18,888	VGG16	97% [30]
Fall armyworm-in- fected maize leaves &Healthy leaf	Unmanned aerial vehicle (UAV)	10,000	Hybrid CNN model	96.98% [31]
Common rust, North- ern leaf blight, Gray leaf spot	Internet	12332	Deep Forest algorithm	96.25% [25]
Maydis Leaf Blight, Turcicum Leaf Blight, Banded Leaf and Sheath Blight, &Healthy leaves	ICAR-IIMR, Ludhiana	5939	Inception- v3_flattenfc	95.42% [20]
Healthy Leaf, Cerco-spora, Northern leaf blight, Common rust	Mohanty plantvillage	200	AlexNet	93.5% [19]
Healthy leaf, Com- mon rust, Northern leaf blight	Plant village, Corn planta- tions in the Raebareli	4382	Model based on realtime deep learn- ing	88.46% [23]
Bacterial spot, Spot- ted spider mite, Leaf mould, Early blight, Septoria leaf spot, Late blight, Yellow leaf curl virus, Targetspot, Mosaic virus.	Plant Villageand Kaggle	10,000	Extreme Learning Machine (ELM)	84.94% [32]

Common rust, North-ern leaf blight, Healthy leaf, Gray leaf spot/Cercospora leaf spot.	Plant village	3837	Multiclass support vec-tor machine	83.7% [33]

3.2 Pre-processing Images

The preparation of the photograph is vital for better results. The color adjustments were made in order to lower noise. Digital camera resizing techniques were utilized to reduce the size of the images that were taken. It also helps to reduce the size of memory. Some frequently used image pre-processing techniques in this literature include removing the leaves of the acquired photographs, altering the color, resizing, eliminating the background, improving the image, flipping, rotating, shearing, and smoothing the image.

3.3 Image segmentation

Image segmentation is crucial for disease classification and identification in leaves of crops. It splits the image up into different areas or sections. It analyzes the visual data to obtain relevant information for feature extraction.

3.4 Extracting features

Feature extraction is the process of obtaining features from an image's component ele- ments. The most common features utilized in disease classification and diagnosis of crop are shape, color, and texture. Crop diseases might appear differently due to many groups. Based only on the structure of the crop leaf image, illnesses may rapidly be identified by the disease system. The second characteristic is the significance of color. It distinguishes between different leaf diseases of crop. The last feature, texture, demon- strates how many color patterns may be observed in leaf cropping images.

3.5 Classification

Crop leaf diseases were categorized using the ML and DL classification methods. Tra-ditional ML does not calculate features automatically, however, in DL, features are extracted automatically and are used as learning weights. Therefore, with Deep Learn-ing, the system itself picks up the necessary traits by receiving enough data.

4 Conclusion

We have examined several research utilizing deep learning and machine learning to identify plant leaf diseases in this work. The process for building the method for iden- tification of crop leaf diseases may be broken down into 5 stages. Among these are picture pre-processing, segmentation, acquisition, extraction of features and classifica-tion. We examined a number of approaches in terms of datasets, crop sizes, accuracy and image count requirements. We also examined performance indicators. Further- more, we draw the conclusion that deep learning-based methods performed better in terms of recognition accuracy and classification speed. The study's conclusions empha- size how important it is in the current agricultural era to integrate computer vision and deep learning. Due to limited resources and the requirement for instantaneous disease detection, further research and datasets must be developed even in cases when the yieldis substantial and includes a variety of diseases.

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