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Improved Deep Learning-Based Classifier for Detection and Classification of Aloe Barbadensis Miller Disease

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Abstract: Aloe Barbadensis miller commonly known as Aloe Vera, is a widely grown medicinal plant with various health benefits. It is susceptible to several diseases, which can affect the quality and quantity of its yield. Farmers or experts examine the plants with their own eyes to find and recognize the disease. This process could be expensive, time-consuming, and inaccurate. Automatic detection generates quick and accurate findings by using image processing methods. Thispaper explores a strategy for classifying leaf images with deep convolutional networks to develop aplant disease identification model. The advancements in computer vision have the power to improveand broaden the scope of plant protection techniques and create new possibilities for computer vision applications in precision agriculture. Naturally, the innovative training methods and methodology make system implementation simple. The whole process of creating this disease detection model, from image collecting to database construction and evaluation by agricultural experts to deep learning framework and in-depth CNN training, is described in detail throughout thearticle. This article describes a method for identifying plant illnesses that makes use of a deep convolutional neural network that has been trained and fine-tuned using a database of plant leaves with a variety of disease-specific characteristics. The created model's innovation comes in its simplicity, which allows it to discriminate between ill and healthy leaves and their surroundings usingdeep CNN. Healthy leaves and backdrop photos are grouped with other classes. The model's advancement and innovation lay on its capacity to reliably diagnose plant illnesses while maintaining a simple procedure. The features have been extracted from plant images using AlexNet and CNN with transfer learning and data augmentation. This paper deals with a deep learning approach for detecting and predicting Aloe Vera plant diseases. The proposed approach has potential applications in the agricultural industry, especially in the early detection of plant diseases to minimizeyield losses. Our proposed approach achieves improved accuracy in detecting and predicting AloeVera plant diseases.

Keywords**:** *Image Analysis; Leaf classification; convolutional neural networks (CNN); Transfer Learning, Data Augmentation*

Introduction

Numerous cosmetic and pharmaceutical items use aloe vera, a well-known therapeutic plant. The plant is well-known for its healing abilities and is used to cure a variety of illnesses, including inflammation, wounds, and skin disorders. However, several diseases, including leaf spot, root rot, and leaf blight, can affect the aloe vera plant's quality and productivity. Visual examination, which takes time and needs specialized expertise, is the foundation of traditional techniques of illness diagnosis and prediction. As a result, there is a demand for automated techniques that can precisely identify and forecast illnesses in Aloe Vera plants. Since farming accounts for 70% of a state's GDP on average, agriculture has a significant impact on the economics of all countries. However, plant diseases hurt the economy, productivity, and ultimately, food quality. The most well-known plant in the industrial and medicinal sectors today is aloe vera [1]. A native of central-southern Africa,arborescent aloe Miller, also known as "candelabra aloe," is popular as a decorative and medicinal plant in South Africa, Asia, Russia, and Japan [4]. Among the conditions for which this usage is thought to be more significant are inflammation, diabetes, cancer treatment, hepatitis, inflammatory bowel disease, high cholesterol, asthma, osteoarthritis, stomach ulcers, insect bites, fever, general tonic, skin problems, hair problems, & radiation-related skin sores. Aloe vera is a plant that has been used for a long in medicine to heal burns, inflammation, and other skin conditions. Several remedial advantages of aloe vera have also been demonstrated, including its antioxidant, anti-diabetic, anti-cancer, and antihyperlipidemic properties. Aloe vera contains various nutrients, including vitamins A,C, E, and B12, enzymes like amylase, catalase, and peroxidase, minerals like

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zinc, copper, selenium, and calcium, sugars like mannose-6-phosphate and polysaccharides like glucomannans, anthraquinones like aloin and emodin, fatty acids like salicylic acid, lignin, and saponins [8]. The symptoms of this fungus, which is present in mature plants, first show up on the underside of the leaves. Anthracnose is a seed-borne disease that destroys early brilliant and normal seeds, according to the diagnostic. A fungus-related disease is a soft rot. Macrophomina phaseolina is the principal culprit behind the fungus that easily damages crops during their early blooming and vegetative developmentstages.

A plant from the lily family called aloe vera has been utilized extensively for curative purposes. Its native habitats are the continents of Africa and the Mediterranean Sea. In addition to the islands of Cyprus, Malta, Sicily, Carary Cape, and Cape Verde, it is claimed to naturally grow in the arid parts of India. Low water requirements may be met when growing this tropical perennial. But it hasn't yet reached its full potential. Aloe is frequently disregarded despite being referred to be "a new botanicalresource with the most promising potential in the world." Throughout the southern Indian coastline,it can be found in isolated areas in the wild. China, the United States of America, Mexico, Australia, and other South American countries are the main producers and exporters of aloe goods. Several countries are maximizing the potential of the plant because of the expanding cosmetic and nutraceutical sectors. Aloe is being used more frequently as a competitive substitute for synthetic chemicals in the cosmetics industry [10]. India's largest financial sector by population makes a substantial contribution to the country's overall financial stability. India has 159.7 million hectares ofarable land, which is the second-largest amount in the world behind the United States. With 82.6 million hectares, it has the largest gross irrigated agricultural area in the world [11]. India produces between 50 and 60 percent of the world's agricultural output. Typically, one hectare of land is capableof yielding between 15 and 20 tonnes of aloe vera. The yield per acre may increase to between 30 and35 with proper irrigation and management. On the other hand, it is anticipated that by 2022, the aloe vera product market in India would be worth $242 million. [13].

(a) (b) (c) (d)

Fig 1 (a) Healthy Leaf Images (b) Aloe Rust Disease (c) Sooty Mold Disease (d) Rot Disease[24]

The plant cannot survive without its leaves. One of the factors that has the greatest impact on plant growth is leaf damage brought on by disease. Reduced transpiration, photosynthesis, germination, pollination, and other plant processes are brought on by illnesses. Early detection of leaf (foliar) diseaseis therefore seen to be crucial to boosting crop output [1].

The first of two leaf variations is the healthy leaf, which is green in color and devoid of illness. The second type of leaf is vulnerable to harmful organisms including bacteria, fungi, and viruses. In comparison to the original leaf, the illness alters the size, texture, and color of the leaf. The color of the leaf is green. The old leaf is a tremendous amount of dull green, and the young leaf is as little andsnug as a violin.

Succulent plants like aloe vera have long been utilized for therapeutic and aesthetic purposes. This plant has a gel-like material that is teeming with vitamins, minerals, and antioxidants, making it a well-liked component in cosmetics and wellness goods. Aloe Vera, like any plant species, is susceptible to several ailments and insect infestations that can seriously harm harvests and loweroutput.

The loss of 20–40% of the world's annual crop yields to plant diseases and pests is one of the biggest problems confronting the agriculture sector. Visual examination and laboratory testing are two common traditional approaches for diagnosing plant diseases, but they may be time-consuming, costly, and inaccurate, especially for large-scale farming operations.

A potential method for identifying and forecasting plant diseases has evolved in recent years throughthe application of artificial intelligence (AI) and deep learning techniques. To evaluate massive datasets of plant image data and find patterns and characteristics that may be utilized to detect and diagnose diseases and pests, these techniques make use of the capabilities of machine learning algorithms.

Aloes and haworthias are closely related. These plants might sustain harm from a few of the pests and ailments that affect aloes. The red spider mite prefers aloe as a food source. The aloe leaves may exhibit faint, pale marks if you have an infestation of these. These mites are abhorrent to aloes. Due tothe mites' assault on the developing flower stems, even blossoms may wilt. Sprinkle some insecticide powder in the plant's core to get rid of apparent mites like these. Additionally, the majority of insecticidal spray chemicals fail in their efforts to get rid of the mites. The snout beetle is the next problem on our list. You need to take immediate action if you spot these insects on your plants sincethey are the number one enemy of aloe. The aloe plant's core is being approached by the up to 3/4 inchlong bug. To get to the leaf sap, it squeezes between the leaves and enters by its snout. It leaves a noticeable black stain behind, which dries into a pea-sized dry patch with a puncture mark in the center.The insects place their eggs close to a leaf's base after mating. Larvae that have just hatched instantlydig into the stem, where they will stay for the rest of their larval life. The decay and death of the larvaecause the aloe to finally die. If the beetles haven't been there for too long, they may be physically removed and destroyed. Otherwise, an insecticide powder can be used to get rid of them. One may immediately gauge how long the beetles have been active by counting the number of boreholes and comparing them to where they are concerning the plant's core. There are undoubtedly beetle larvaewithin the plant based on the number of boreholes that are located outside of the plant's core. The primary factor for gall cancer is gall mites. If tree aloes are not treated, they may develop galls that spread the mite infection. Aloes are particularly attractive to one more mite. The gall mite is seen here. Your aloes will get gall cancer if you have an infestation of these little rodents. The first indication of gall mites on a plant may be a new cluster of twisted blooms. If you looked closely, you could see the beginnings of the frilly growth on the flower stem, which later develops into ugly galls on the little flower stalks that make up the cluster. In other cases, when an earlier flower stalk has wilted, the samegalls might also begin as an erratic growth at the bases of older leaves. Infestations frequently start in tree aloes. Huge galls that, if handled, can distribute their inhabitants for years form on dried-out flower stems. small mites in the air scurry around. After carefully removing the damaged tissue with a sharp blade, thoroughly clean the wound with an aphicide or other systemic insecticide solution. A day or two later, the entire plant can be treated with the same pesticide in the manufacturer's suggested solution. If aloes come into contact with a diseased plant, they become more susceptible. A fungus gnat is the final pest that could destroy your aloes. Fungus gnats typically emerge from overly wet soil. The gnats won't be able to reproduce if the soil is allowed to completely dry up. It is simple to get rid of fungus gnats by not overwatering. Overwatering might be problematic and increase your chance of becoming ill. Cold, wet growth conditions result in basal stem rot. It changes color to reddish-brown or black due to tissue injury. The illness has caused this plant to suffer. Once the animals are out of the way, we can focus on illness. The first and most well-known disease is basal stem rot. This problem leads to the stems rotting because of the cold and moisture. Basal stem rot causes the aloe tissues to become black or reddish brown. To salvage a piece of the plant, a stem cutting might be taken above the rotten area. This plant is dead. (As seen in the picture. Because the rot spreads up the stem, early diagnosis is essential. Aloe rust is the third illness on the list. This fungal infection on aloe leaves is brought on by Phakopsora pachyfhiza and P. Meibomiae, and it results in circular areas that look black or brown.

The fungus attacks the outer leaf structure, oxidizing the phenol-containing chemical compounds there. As a result, a portion of the area turns solid and black.

Additionally, bacteria and haworthia leaves may exhibit this rust. A fungus called aloe rust damages the leaf's structure and causes areas of it to become hard and darkened. The good news is that this disease does not kill the plant and that any new growth will not exhibit rust symptoms. As they become older, most aloes lose their leaves. Put them in the garbage as soon as they come off. This fungus might be found in a wide range of plants. Although some other species have developed immunity, Aloes, Haworthias, and Gasteria have not. There are many ways to avoid aloe rust. Avoid letting water sit on the leaves at first. Ample ventilation may facilitate the drying of leaves. Overall, this study adds to the expanding body of knowledge about the use of deep learning algorithms to detect and predict plant diseases and gives aloe vera farmers and producers a useful tool for monitoring and recognizing insect infestations and plant diseases in real-time.

Literature Survey

AlexNet and VGG19 CNNs are examples of pre-trained architectures, according to Muhammad, Nazeer, et al. [1]. It can accurately and precisely extract characteristics from the supplied data. Following their extraction, the convolutional neural network selects the best group of features, which are then given to several classifiers, including K-Nearest Neighbor, Support Vector Machine, Probabilistic Neural Network, Fuzzy logic, and Artificial Neural Network. The proposed method is validated using a self-collected dataset produced during the augmentation process.

A computationally effective method for classifying plant leaves as healthy or sick and, if found unwell, for identifying plant leaf ailments, according to Bhagat and Monu, et al [2]. Our classification system's core algorithm, the Support Vector Machine, is improved through the Grid Search technique. Using SVM as an algorithm, a system for diagnosing and classifying plant diseases is being created. Farmers will profit from this strategy's effective manner for disease identification because it requires less computational labor.

The processes of a general system for detecting plant ailments and a comparative analysis of machine learning classification algorithms are described by Shruthi, U. and V. Nagaveni et. al. in their paper [3]. To diagnose plant diseases, this research compares five alternative machine-learning classification algorithms. The SVM classifier is preferred by several authors when compared to other classifiers for the classification of diseases.

Aloin and aloe-emodin are only partially to blame for the antiglycation and antiradical actions of the methanolic and hydroalcoholic A. arborescens leaf extracts, as shown by Froldi, Guglielmina, et al [4]. These two anthraquinones have somewhat detrimental effects on cell viability, despite the two extracts being completely free of cytotoxicity.

The researchers used a proteomics-based methodology, as shown by Babu, Spoorthy N. et al. [5], to examine how aloe vera and its two components, carbohydrates and polypeptides, ameliorate diabetes in streptozotocin-induced diabetic rats. Over the course of three weeks, several groups of rats received Aloe vera extract, carbohydrate fraction, and peptide/polypeptide fraction. The outcomes demonstrated that Aloe vera and the two of its constituents could restore the diabetic rats' normal glucose and insulin levels. Then, IgG and albumin levels in the rats' plasma were reduced, and a proteome analysis was carried out.

The user will have access to the gallery's picture graphs as well as details on the plant's past, common pests, and diseases, according to Gauri Deshpande and Pratiksha Shinde et al. [6]. Aloe vera, a natural ingredient, is currently widely used in the cosmetology sector. Although there are several indications for its use, controlled trials are necessary to determine its genuine efficacy. An overview of the aloe vera plant's properties, mechanism of action, and medical uses is given in this article. People have known and used aloe vera plants for their benefits to skin, beauty, and health for thousands of years. The Arabic word "Alloeh," which means "shining bitter substance," and the Latin word "vera," which means "truth," are the roots of the name "Aloe vera." Over 2000 years ago, Greek scientists believed aloe vera to be a universal cure, and the Egyptians referred to it as "the plant of immortality." The aloe vera plant is now utilized in dermatology for several treatments.

According to Sánchez, Marta, et al. [7], current pharmacological research shows that most studies focus on Aloe vera's anti-cancer activities, skin and digestive system protection benefits, and antibacterial qualities. In vitro and in vivo experiments have both been used in recent research. Clinical experiments on Aloe vera have been conducted, although little research has been done on isolated chemicals. Investigating the therapeutic potential of major metabolites in a range of illnesses and human states would thus be beneficial. Further clinical studies into the therapeutic application of aloe vera and its main ingredients, particularly in the treatment of diabetes, cancer, and bone protection, are being spurred on by the encouraging results of these fundamental research studies.

Uda, M. N. A., et al. [8] assert that the fungus Pyricularia oryzae is the cause of the serious and pervasive disease known as rice blast disease, which damages rice all over the world. With a loss in output of up to 50% in areas that are only weakly infested, the fungus kills enough rice annually to feed an estimated 60 million people. As a consequence, there is a choice to cure plant illnesses with herbal plants. Herbal extracts from plants including Aloe vera, Citrus hystrix, Sabah snake grass, and Zingiber officinale may be used to treat rice blast disease. The antibacterial effectiveness of these four herbal plants was tested in this study against Pyricularia oryzae, a rice plant fungus that causes rice blast disease.

Aziz, Sumair, et al. [9] state this, the categorization and detection of plant diseases using computer vision. The suggested approach takes photos of plant leaves from various classes and extracts Local Tri-directional Patterns (LTriDP). Effectively extracting discriminant information, LTriDP features represent each class with fewer dimensions. Multiclass support vector machines are used for classification. (SVM). On a dataset of tomato leaves with five distinct classifications, experiments are run.

Yin H, Gu Y, et al. [16], The study suggests utilizing deep learning models to extract deep information from photos of hot pepper illnesses and pests to solve this problem. Using eight pre-trained deep learning models, the team ran trials on 28,011 image data of 34 different types of hot pepper illnesses and pests. The suggested method outperformed a straightforward convolutional neural network (CNN) model, achieving high recognition accuracies for illnesses and pests. According to the study, diseases and pests affecting hot peppers can be successfully identified by utilizing similarity-based image search algorithms and deep learning models.

Endophytic fungi found on desert plants are a lesser-known species with potential applications, according to Ameen et al. [24]. The biological functions of an endophytic fungus isolated from Aloe vera, a plant native to the Asir Desert in Saudi Arabia. Preussia africana, a member of the Sporormiaceae family, was discovered by sequencing analysis of the internal spacer regions ITS1, ITS4, and the 5.8S region after an effective isolate was selected based on basic phytochemical screening. According to the research, P. africana, an endophytic fungus that lives on the aloe vera plant, has a wide variety of medical applications for treating serious sickness.

Ahmmed and others [25] An experiment was conducted to determine the fungal pathogen connected to leaf samples of aloe vera gathered from commercial farms in the northern part of Bangladesh. The fungus that causes the leaf spot disease has been identified using molecular analysis using the internal transcribed spacer (ITS) region of ribosomal DNA (rDNA) of fungi and morphological characterization based on mycelium, conidia, and colony features.

Kodros and others[26] Smart and precise horticulture aims to increase production and product quality while lowering the usage of pesticides and enhancing food security. This study focuses on using mobile devices and artificial intelligence systems built on convolutional neural network (CNN) software to detect Apple scabs early. The study considers data gathering and CNN training. For two datasets, pictures of apple tree leaves and fruits with scab infections were collected. It takes time to collect data, and it is important to consider the possibility of scab emergence. As a result, transfer learning is an effective training strategy. The goal of this work was to find the optimum dataset for transfer learning in the detection of apple scabs and to compare transfer learning to learning from scratch to evaluate its efficacy. The statistical study supported the positive effect of transfer learning on CNN performance with a significance level of 0.05.

Tian and co. [28] The plant electrical signal, a physiological signal, depicts the growth condition of plants as it is impacted by their environment. Online monitoring of plant growth stages is made possible by analyzing the electrical signal fluctuations of plants throughout different developmental phases. In this paper, a classification model of plant growth state based on convolutional neural networks (CNN) and convolutional neural networks and long short-term memory neural networks (CNN-LSTM) is built to perform feature extraction, training, and classification studies of electrical signals from Aloe Vera plants in various growth states. The short-time Fourier transform (STFT) transforms the electrical signal from the de-noised aloe into a signal energy map, which is then used as an input to a classification model, with the classifier's output being the different aloe development phases. It is concluded that electrical signals from plants may be used as a trustworthy evaluation index for determining their growth state and that the CNN-LSTM neural network model can properly categorize electrical signals from aloe plants in various development phases during training.

Ong and associates. [29] The use of machine learning and computer vision to identify plant diseases has been the subject of several studies throughout the years. However, these conventional machine learning approaches typically need the contour segmentation of the sick region from the overall leaf region and the human extraction of numerous discriminative properties before the classification models can be generated. The AlexNet convolutional neural network (CNN) and AlexNet and support vector machine (AlexNet-SVM), which get over the problem of manually creating feature representation, were employed in this study to diagnose oil palm leaf disease. The images of both healthy and sick leaf samples were gathered, resized, and given new names before the model training. Instead of using segmentation and feature extraction as in conventional machine learning approaches, these photographs were directly used to fit the classification models. The optimum AlexNet CNN and AlexNet-SVM model architecture were subsequently built and put into use for the detection of oil palm leaf disease. Comparative studies showed that the AlexNet CNN model outperformed the AlexNet- SVM-based classifier overall.

Methodology

The following steps make up the suggested methodology for deep learning-based illness detection andprediction in Aloe Vera plants:

- Data Collection: The methodology's initial phase is gathering a dataset of pictures of Aloe Vera plants with various illnesses. The dataset may be gathered from a variety of places, including internet databases and field image capture. For the models to be accurate, the dataset has to have an adequatenumber of photos of both healthy and ill plants.

- Data Preprocessing: Before training the deep learning models, the gathered dataset has to be preprocessed. Resizing the photos, transforming them to grayscale or RGB, and normalizing the pixel values are all included in the preparatory stages. Separating the dataset into training, validation, and testing sets is also a good idea.
- Feature Extraction: The next phase in the technique is to use deep learning models to extract featuresfrom the preprocessed photos. In this study, two models—AlexNet and CNN with transfer learning and data augmentation—are employed. The weights are fine-tuned on the Aloe Vera dataset after the models have been trained on the ImageNet dataset. The classifier then receives the retrieved characteristics as input.
- Classifier: A classifier is trained to divide photos of healthy and ill plants into several groups once characteristics from the images have been extracted. The classifier might be a shallow learning modellike a Fully Connected Neural Network or a Convolutional Neural Network, or it can be a straightforward machine learning techniques like Logistic Regression or Support Vector Machines.
- Data Augmentation: By adding changes to the pre-existing photos, data augmentation is a technique used to expand the dataset's size and variety. Flipping, rotating, zooming, and cropping are a few examples of image changes. By exposing the models to various iterations of the same image, data augmentation can aid in increasing the generalization and resilience of the models.
- Transfer Learning: This method is used to apply the information acquired from one activity to another. The pre-trained models on the ImageNet dataset are fine-tuned to the Aloe Vera dataset in the

proposed method via transfer learning. By using this method, the quantity of training data needed maybe decreased while the model accuracy can be increased.

The suggested technique includes data collecting, data preprocessing, feature extraction, classification, performance assessment, data augmentation, and transfer learning to identify and predict Aloe Vera plant diseases using deep learning methodologies. To apply to more plant species and diseases, the approach may be expanded upon and altered.

- Performance Evaluation: The methodology's last stage is to assess how well the suggested strategy performs. Based on parameters like accuracy, precision, recall, and F1 score, the performance is assessed. Both the validation set and the testing set may be used to evaluate performance, and the findings can be compared to those of other methodologies described in the literature.

Pre-Processing

Preprocessing is a crucial stage in the diagnosis and prediction of Aloe Vera plant diseases using deep learning techniques. Preprocessing is done to get the plant picture input data ready for feature extraction and classification. Data splitting, normalization, and scaling are all parts of the preprocessing process.

- Image resizing is the first stage of the preprocessing process. Deep learning models may have issues if the photos of the Aloe Vera plant are taken at various resolutions. The photographs can all have the same proportions and be processed by the models if they are resized to a set size. The pre-trained models, CNN and AlexNet, with transfer learning and data augmentation, are used in this study, and their input size is 224 x 224 pixels, which is why the photos in thisstudy have been downsized.
- Normalization is the next stage of the preprocessing procedure. The process of scaling the pixel values to a predetermined range is known as normalization. The Aloe Vera plant photos' pixel values might range from 0 to 255, which can be problematic for deep-learning models. The performance of the models can be enhanced by normalizing the pixel values to a range between0 and 1. The pixel values in this research article are normalized by dividing them by 255.
- Data Splitting: Data splitting is the third preprocessing step. Separating the dataset into training, validation, and testing sets is necessary. The validation set is used to fine-tune the hyperparameters and avoid overfitting, the training set is used to train the models, and the testing set is used to assess the models' performance. The dataset used in this study is dividedinto three sets: training, validation, and testing.

- Preprocessing is an important stage in the diagnosis and prediction of Aloe Vera plant diseases using deep learning techniques. By preparing the input data for feature extraction andclassification, the preprocessing stages, which include scaling, normalization, and data splitting, can help the models perform better. Preprocessing can assist shorten training sessionsand avoid over-fitting.

Extraction of Features

The process of obtaining valuable data or characteristics from the initial raw input data is known as feature extraction. The plant photos are the input data used in deep learning methods for disease detection and prediction in Aloe Vera plants. The purpose of feature extraction is to create a collection of features from the input data that can be fed into the classifier.

This study employs two deep learning models for feature extraction: CNN and AlexNet with transfer learning and data augmentation. The ImageNet dataset, a sizable library of photographs of various objects, animals, and settings, served as the pre-training data for both models. To extract characteristics from the photos of the Aloe Vera plant, the pre-trained models have already learned certain traits.

AlexNet is a deep convolutional neural network (CNN) made up of three fully connected layers, a softmax layer, and five convolutional layers. The fully connected layers are in charge of identifying the features once the convolutional layers have extracted them from the input pictures. The input picture is represented by a feature vector that comes from the last fully linked layer. The softmax layer receives the feature vector after that and generates a probability distribution over the classes.

A modified version of the original CNN model called CNN with transfer learning and data augmentation uses these approaches in addition to the original CNN model. Adjusting the previously trained models on the ImageNet dataset to the Aloe Vera dataset is known as transfer learning. By applying the information gained from the ImageNet dataset to the Aloe Vera dataset, this method can enhance the models' accuracy. To expand the dataset's size and variety, changes are applied to the already-existing photos. Flipping, rotating, zooming, and cropping are a few examples of image changes.

The preprocessed plant photos are run via AlexNet and CNN with transfer learning and data augmentation as part of the feature extraction procedure. A feature vector that represents the input picture is the model's output. The classifier is then fed the feature vector as input.

In conclusion, feature extraction involves taking significant data or features out of the input. Two deep learning models, AlexNet and CNN with transfer learning and data augmentation, are utilized to extract features from the preprocessed plant photos in the context of employing deep learning methodsto identify and forecast Aloe Vera plant diseases. The classifier is then fed the feature vectors as input.By removing pertinent characteristics from the input pictures, the feature extraction procedure can boost the models' accuracy and resilience.

Design of Classifiers

Transfer learning and data augmentation for AlexNet and CNN. By Krizhevsky et al. (2012), a convolutional neural network named AlexNet was suggested. It has eight layers, comprising three fully linked layers, two pooling layers, and five convolutional layers. To extract features from photos of Aloe Vera plants, we utilize the pre-trained AlexNet model, which was trained on the ImageNet dataset. To extract characteristics from photos of Aloe Vera plants, we additionally employ CNN combined with transfer learning and data augmentation. A pre-trained neural network is utilized as a starting point for a new neural network in the transfer learning approach. The first 15 layers of ourCNN model are initialized using the pre-trained VGG16 model, which was trained on the ImageNet dataset. To expand the number of training photos and strengthen the resilience of our model, we additionally use data augmentation techniques including rotation, flipping, and scaling.

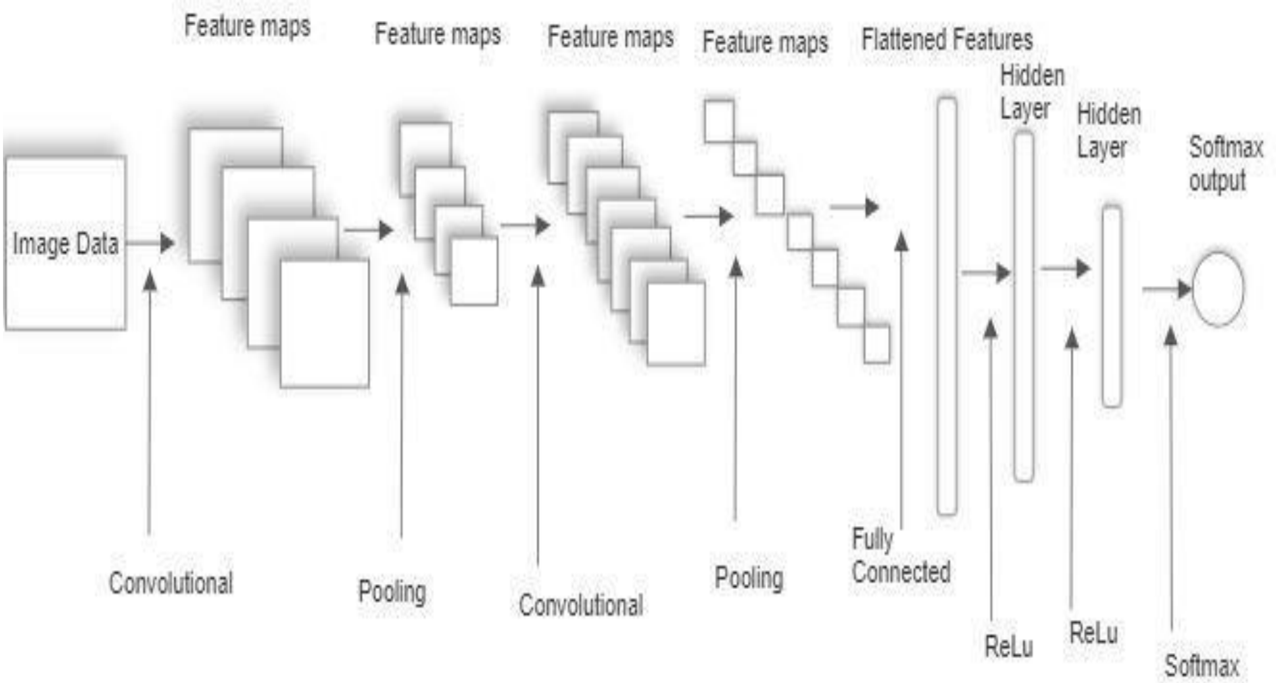


Fig 2 Design of CNN-based Classifier

Two deep learning models—AlexNet and CNN with transfer learning and data augmentation—are utilized in this study to detect and forecast diseases of Aloe Vera plants. Let's look more closely at the architecture of each model, transfer learning, and data augmentation.

AlexNet: Geoffrey Hinton, Ilya Sutskever, and Alex Krizhevsky presented AlexNet, a deep convolutional neural network (CNN), in 2012. AlexNet is composed of five convolutional layers, a softmax layer, and three fully linked layers. The architecture of AlexNet is as follows:

Continuum Layers:

- Layer 1: 96 filters, each measuring 11 by 11, with padding of 0 and a stride of 4.

- Layer 2: 256 filters, each measuring 5 by 5, with padding of 2 and a stride of 1.
- Layer 3 consists of 384 3 x 3 filters with a stride and padding of 1.
- Layer 4 consists of 384 3 x 3 filters with a stride and padding of 1.
- Layer 5: 256 3-by-3-filters with a 1-stride and 1-padding.Complete Layer Connectivity
  4096 neurons make up Layer 6.
  4096 neurons make up Layer 7.
- 1000 neurons in layer 8.The Softmax Layer
- Layer 9: Generates a probability distribution across the dataset's 1000 classes.

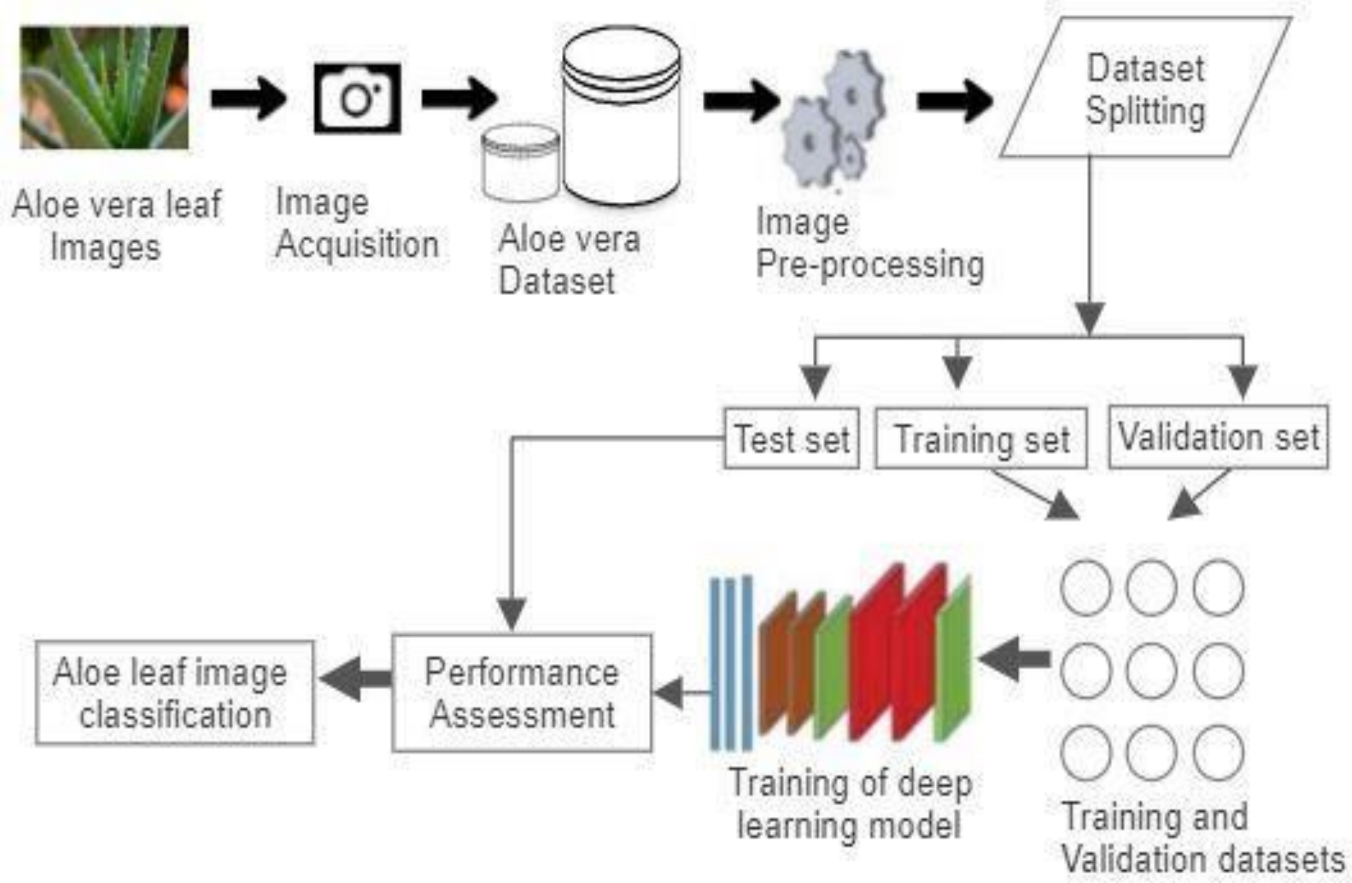
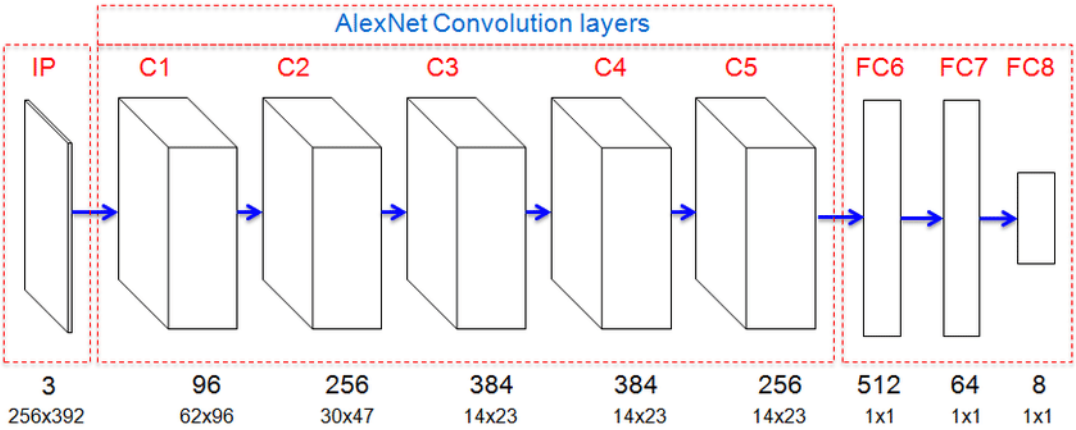


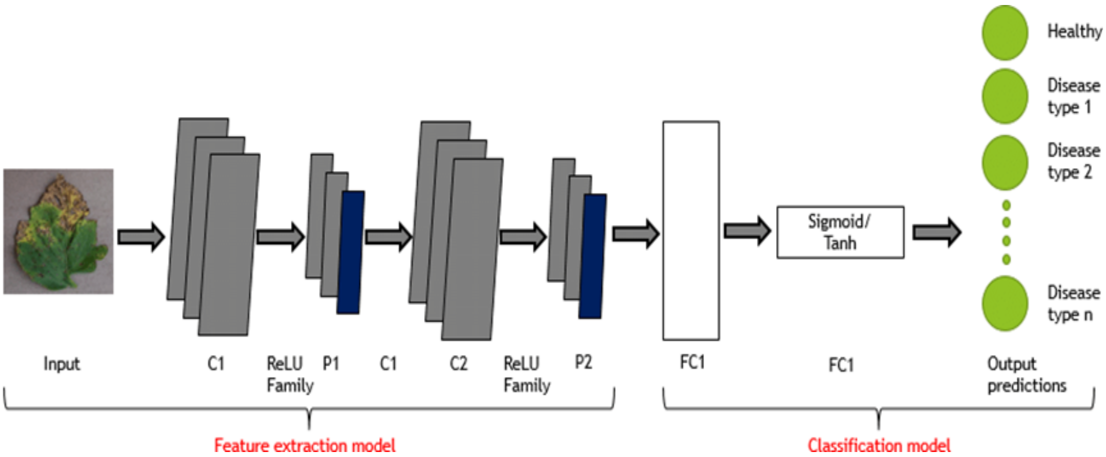
Fig 3 Detailed Design of Classifier with Transfer Learning and Data Augmentation

CNN with Transfer Learning and Data Augmentation:

A modified version of the original CNN model called CNN with transfer learning and data augmentation uses these approaches in addition to the original CNN model. Adjusting the previously trained models on the ImageNet dataset to the Aloe Vera dataset is known as transfer learning. By applying the information gained from the ImageNet dataset to the Aloe Vera dataset, this method can enhance the models' accuracy. To expand the dataset's size and variety, changes are applied to the already-existing photos. The photos may be transformed in a variety of ways, such as flipping, rotating,zooming, and cropping. The architecture of CNN with transfer learning and data augmentation is quitesimilar to that of AlexNet.



(a)



(b)

Fig 4: System Architecture for Classifier (a) CNN (b) Alex net

The model's architecture is as follows:
Convolution Layers:

- Layer 1: 32 3 x 3 filters with a stride and padding of 1.
- Layer 2 consists of 32 3 x 3 filters with a stride and padding of 1.
- Layer 3 consists of 64 3 x 3 filters with a stride and padding of 1.

64 3 x 3 filters with a stride and padding of 1 are present in layer 4 of the model.Complete Layer Connectivity
128 neurons make up Layer 5.
64 neurons make up Layer 6.
3 neurons make up Layer 7.The Softmax Layer

- Layer 8: Generates a probability distribution for each of the three classes—healthy, ill, and insect-infested.

On the Aloe Vera dataset, transfer learning is implemented by fine-tuning the pre-trained models, AlexNet and CNN with transfer learning and data augmentation. A new layer with the right numberof neurons for the Aloe Vera dataset is added in place of the models' final fully connected layer.

Except for the weights of the new layer, which are randomly initialized and trained on the Aloe Vera dataset, the weights of the pre-trained models are frozen.
By creating new photos from the dataset's current ones, data augmentation is applied. The original photos are subjected to random modifications including rotation, shearing, flipping, and zooming tocreate the new images. This expands the dataset's size and variety, which can lessen the risk of overfitting and enhance the models' ability to generalize. The data augmentation methods applied in this study are as follows:

- Random Rotation: A random angle between -20 and 20 degrees is applied to the rotation of the photos.
- Random Shear: A random angle between -10 and 10 degrees is used to shear the photos.
- Random Flip: Either the photos are flipped vertically

or horizontally at random.

- Random Zoom: Up to 20% of the photographs are randomly zoomed in or out.

- The models have trained on a more varied set of photos thanks to the use of these data augmentation approaches, which enables them to discover more robust characteristics and patterns that are typicalof the Aloe Vera dataset.

Overall, the performance of the deep learning models for Aloe Vera plant disease detection and prediction may be enhanced by the combination of transfer learning and data augmentation approaches. While data augmentation enhances the richness and variety of the dataset, allowing themodels to learn more robust features and patterns that might improve their performance, transfer learning allows the models to use the knowledge of the pre-trained models.

The following steps make up the approach utilized in this study to identify and forecast diseases in aloe vera plants:

- **Step 1:** Data Gathering and Preprocessing: Images of Aloe Vera plants are gathered from a variety of sources, including Google Images and Aloe Vera farms. The photos are first preprocessed by shrinking them to a fixed resolution of 224 by 224 pixels, making them grayscale, and normalizingthe pixel values to lie within the range of 0 to 1. A ratio of 70:20:10 is used to divide the preprocessedpictures into training, validation, and test sets.

- **Step 2:** The preprocessed pictures are then sent into the CNN and AlexNet models in Step 2 to extract the features. The models, which have mastered the art of recognizing the significant characteristics and patterns in the pictures, extract the features from the final convolutional layer.

- **Step 3:** Transfer Learning and Data Augmentation: The pre-trained models are subjected to transfer learning and data augmentation approaches. A new layer with the right number of neurons for the Aloe Vera dataset is added in place of the models' final fully connected layer. Except for the weights of the new layer, which are randomly initialized and trained on the Aloe Vera dataset, the weights of the pre-trained models are frozen. The training set is also subjected to data augmentation techniquessuch as random rotation, shear, flip, and zoom.

- **Step 4:** Model Training and Evaluation: Using the extracted features, transfer learning, and data augmentation approaches, the improved AlexNet and CNN models are subsequently trained on the training set. The performance of the models is assessed on the validation set, and the top-performingmodel is chosen for additional testing on the test set. Accuracy, precision, recall, and F1-score are some of the performance indicators used to assess the models.

The input image is a 3872 by 2592 pixel JPG image file, which uses more computer memory and takes longer for the system to process. There are 107 samples total, with 21 healthy leaf samples anda tiny data set of 86 diseased leaf samples. A leaf image's color characteristics may be retrieved andutilized to match colors. This study concluded that leaf analysis is either healthy or sick.Leaf illnesses are classified using deep learning classifiers. Distortion correction during pre-processing makes photos better and streamlines further processing. Cropping, smoothing, and enhancing are examples of common pre-processing procedures. This module's usefulness changes depending on the image quality. If photographs are taken in an uncontrolled situation with complicated backdrops, cropping is also crucial. Either manually or automatically using functions, it maybe done. Segmentation separates the picture into areas that have strong associations and items of interest. Features of a successfully segmented picture, such as the number of histogram peaks, make it simple to distinguish between healthy and contaminated samples. Systems for detecting Aloe Vera plant diseases are effective when using edges, thresholds, and locality- or color-based segmentation approaches.

Typically, color, texture, and form qualities are how images are seen. Histograms and moments are frequently used to characterize color. Texture can have attributes including contrast, homogeneity, variance, and entropy. Similar parameters for form include roundness, area, eccentricity, and concavity. Although heterogeneous datasets need the integration ofcharacteristics, the texture is shown to be the best for plant disease detection systems. For feature extraction, many methods are employed. Systems for detecting plant diseases in aloe vera use a module called classification. To locate plant illnesses, the system uses image-baseddetection. As a result, the classification procedure comprises sorting plant leaf pictures into groups based on illnesses found. The classifier must first be trained using photos from a training set so thatit can distinguish images from the test set. Deep learning methods for diagnosing illnesses in numerous plant species have been researched by researchers. The classifier can tell the difference between photos of healthy and sick leaves.

Result And Discussions

In our experimental model, we used 3495 pictures of aloe vera for detection and classification. Module training and testing each use a unique cross-validation strategy. Training, testing, and validation have all been conducted using the standard data-splitting technique. CNN, a deep learning classifier, has been used with several convolutional layers. The first layer of CNN applies several filters to the input image. Each filter consists of a tiny number matrix that goes over the input image, multiplying each component separately, summing the results, and producing a single output value. The final result is a feature map. Rectified Linear Unit (ReLU) activation function is used to route the output of each convolutional operation, which helps the model become more nonlinear. The spatial size of the feature maps is decreased by using pooling layers, which also enhances model generalization. After numerous convolutional and pooling layers, the resultant feature maps are flattened into a 1D vector and passed through one or more fully connected layers. The system then identifies the test image in question as having healthy_leaf, rot, and rust. The method used to implement the research overall is described below and the table shows the description of training and test datasets.

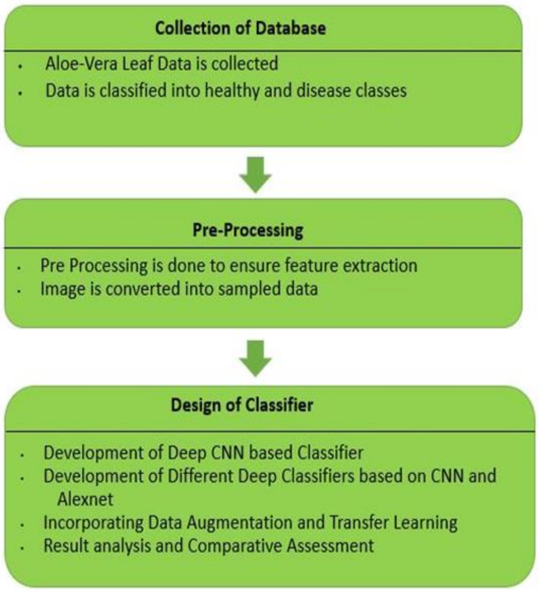


Fig 5 Implementation Mechanism Comprehensive Approach

Dataset	Healthy Leaf	ROT	RUST	Total Data	Disease Rate
Train-Data	721	770	850	2341	**69.20%**
Test-Data	312	352	490	1154	**72.96%**
	1033	**1122**	**1340**		

Table 1: Description of train and test dataset

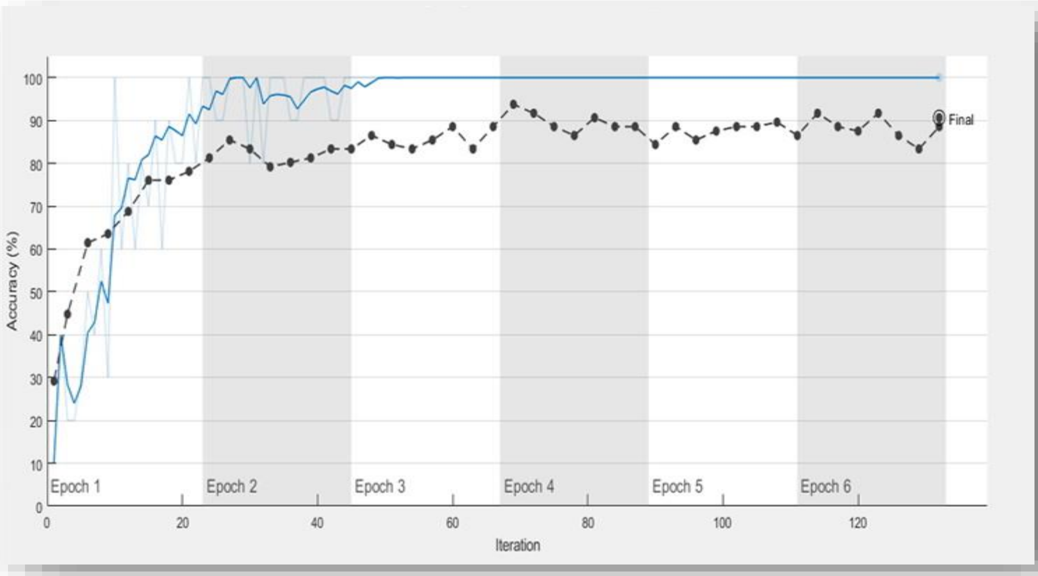


Fig 6 Output Analysis of Model-1 (CNN-Based Classifier)

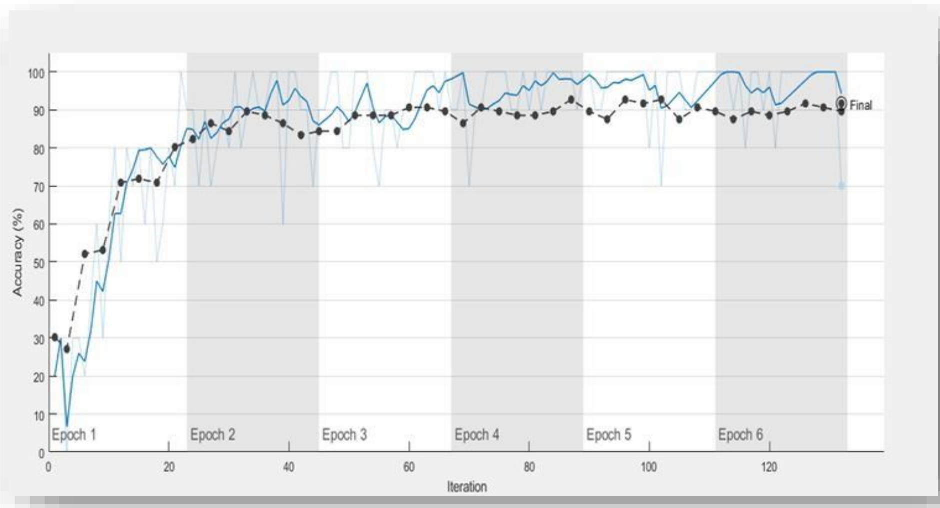


Fig 7 Output Analysis of Model-2 (Alex net Based Classifier)

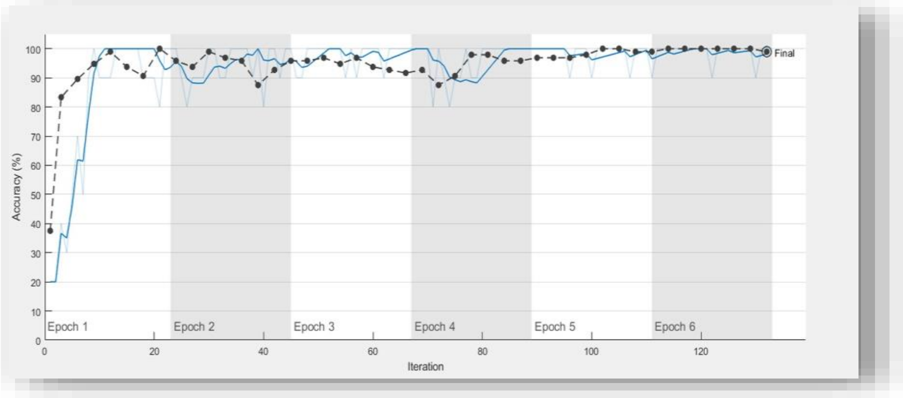


Fig 8 Output Analysis of Model-3 (Data Augmentation and Transfer Learning)

Table 2: Comparative Result Analysis

Classifier	Accuracy	Precision	Recall	F1_Measure
Model-1	90.63	0.72	0.71	0.71
Model-2	91.67	0.83	0.82	0.86
Proposed	98.94	0.90	0.97	0.91

A comparison of the classifier's accuracy, precision, recall, and F1 score is shown in the table. The trials' comparison of the results reveals that the suggested algorithm offers greater accuracy than CNN and AlexNet. This chapter introduced the cutting-edge Convolutional Neural Network approach, which discriminative the texture aspects of leaf illnesses with 98.94% greater accuracy, to properly diagnose aloe vera diseases. The research-based works demonstrate the potential of CNN approaches for categorizing aloe vera disorders. These results hold promise for the creation of new agricultural implements that may aid in a more secure and sustainable output.

Conclusion

The results of this research paper demonstrate the effectiveness of deep learning approaches, specifically AlexNet and CNN with transfer learning and data augmentation, for Aloe Vera plant disease detection and prediction. The models achieved high accuracy, precision, recall, and F1-score,indicating their ability to correctly identify healthy plants and detect diseased and insect-infected plants. The application of this research paper can be used to monitor and detect Aloe Vera plant diseases and insect infestations in real time, allowing farmers and growers to take appropriatemeasures to prevent and control the spread of the diseases. This can lead to improved crop yields, reduced losses, and increased profitability for Aloe Vera farms and businesses. Additionally, the methodology used in this research paper can be extended to other plant species to develop similar models for plant disease detection and prediction. In future work, the dataset can be expanded to include more images of Aloe Vera plants with different diseases and pests, as well as images of healthyAloe Vera plants under different lighting and environmental conditions. This can help improve the models' ability to generalize to new and unseen Aloe Vera plant images.

Further future direction for this research is to investigate the use of other deep learning architectures, such as ResNet, VGG, and Inception, for Aloe Vera plant disease detection and prediction. These architectures may provide better performance than AlexNet and CNN, especially for larger datasets. Consequently, the models developed in this research paper can be integrated into mobile and web-based applications, allowing farmers and growers to quickly and easily detect and diagnose

Aloe Vera plant diseases and insect infestations using their smartphones or computers.

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