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ABSTRACT

Detecting diseases in tea leaves can be achieved using deep learning models. The first step is to collect a dataset of tea leaves images with and without diseases. The dataset should have a good distribution of images with different types of diseases to ensure that the model can learn to distinguish between healthy and diseased leaves. Once the dataset is ready, you can use a convolutional neural network (CNN) to train a deep learning model.

CNNs are particularly suited for image recognition tasks, as they can learn to extract meaningful features from images. In the case of tea leaves, the model will learn to identify patterns and textures that are indicative of diseases, such as discoloration, spots, or unusual shapes. The output of the model will be a probability score indicating the likelihood of a tea leaf being diseased.

To improve the accuracy of the model, you can use techniques such as data augmentation, transfer learning, or ensembling. Data augmentation involves generating new training samples by applying transformations such as rotations, flips, or zooms to the original images. Transfer learning involves using a pre-trained model as a starting point and fine-tuning it on the tea leaves dataset. Ensembling involves combining the predictions of multiple models to produce a more robust and accurate final prediction.

Overall, deep learning models can be a powerful tool for detecting diseases in tea leaves, but they require a significant amount of data and expertise to develop and deploy.

Chapter 1

1.INTRODUCTION

1.1.Project Overview:

Tea is one of the essential beverages in Bangladesh. Mostof the Bangladeshi people start their day with a cup of tea. Bangladesh has become an important tea producing Country.Today the country has 172 commercial tea estates [1].The districts that produce tea are Maulvibazar,Habiganj,Sylhet,Chittagong, Panchagarh, Brahmanbaria, and Rangamait [2]. Almost the entirety of the district of Sylhet is the standard tea garden area and Srimangal is known as the tea capital of Bangladesh [3]. Tea is the second largest export based cash crop of Bangladesh. The industry accounts for 1% of the national GDP of Bangladesh [4]. Tea production in Bangladesh is greatly hindered due to a number of pests and diseases, caused by a variety of insects, mites, nematodes,bacteria, algae, fungi, weeds, and other diseases which arecaused due to the environmental condition of that particular region .

Bangladesh is an agricultural country where more than 75% population rely on agriculture directly or indirectly [4]. Approximately 20% to 30% of the tea leaves are lost due to various diseases each year [5]. Farmers in the field judge the identification of tea leaf diseases with their naked eye and previous experience. Many a times, experts are needs to be called in to analyze the tea leaves when there is ambiguity in detecting the diseases by local farmers; this process is not only time consuming, but also costly. It is important to catch the spread of the disease in its early stages before they reach epidemic proportions; otherwise the disease can spread quickly throughout the entire plantation, resulting in huge losses for the farmers. To aid the farmers in the crucial task of identifying tea leaf diseases in their infancy, it is practical to have an intelligent system of detection,identification, and classification system in place as a preventative measure. The first sign that something is wrong with the leaf is usually indicated by a change in color from a healthy dark green hue. When the tea leaf is healthy the color is distinct, but when the leaf is affected by disease, the color of the leaf changes drastically. Each disease usually has a distinguishable leaf color and texture as symptoms.The latest trends of research in agriculture are toward the use of gene technology to develop disease resistant variant of the plant, and to increase food quality and productivity of the plant with reduced expenditure . Numerous technological improvements are responsible for the progress in crop management techniques in recent times; including advances in information technology, remote sensing technology, and image processing and pattern recognition [6-7].Therefore, now it is possible to develop and deploy an autonomous system for detection, identification, and classification of diseases in crops in very large fields with minimal manual input. A search through recent literature have identified research in various types of crop diseases including diseases in rice, citrus, Betel vine, and wheat leaf to name a few [8]. However, research into diseases of tea leaves is one area that has not yet seen any significant efforts. Therefore, there should be a way to developtea leaf disease recognition and detection to help the tea industry in Bangladesh. In this paper, Support Vector Machine classifier is used to recognize the diseases of tea leafs.

1.2 Purpose

The objective for detecting diseases in tea leaves is to identify and manage any plant diseases that could potentially reduce tea production and quality. Disease detection is critical for tea plantation management as it allows farmers to take timely action to prevent or control the spread of disease, thus minimizing crop damage and improving yield and quality. There are various methods for detecting diseases in tea leaves, including visual inspection, laboratory analysis, and remote sensing technologies. Visual inspection involves examining the plants and leaves for any visible signs of disease, such as discoloration, lesions, or abnormal growth. Laboratory analysis involves taking samples of the plant tissue and testing for the presence of pathogens or other indicators of disease. Remote sensing technologies use various sensors, including satellites and drones, to detect changes in plant health and identify areas of stress or disease. Overall, the objective of disease detection in tea leaves is to enable farmers to manage plant health and maintain high-quality tea production.

CHAPTER – 2

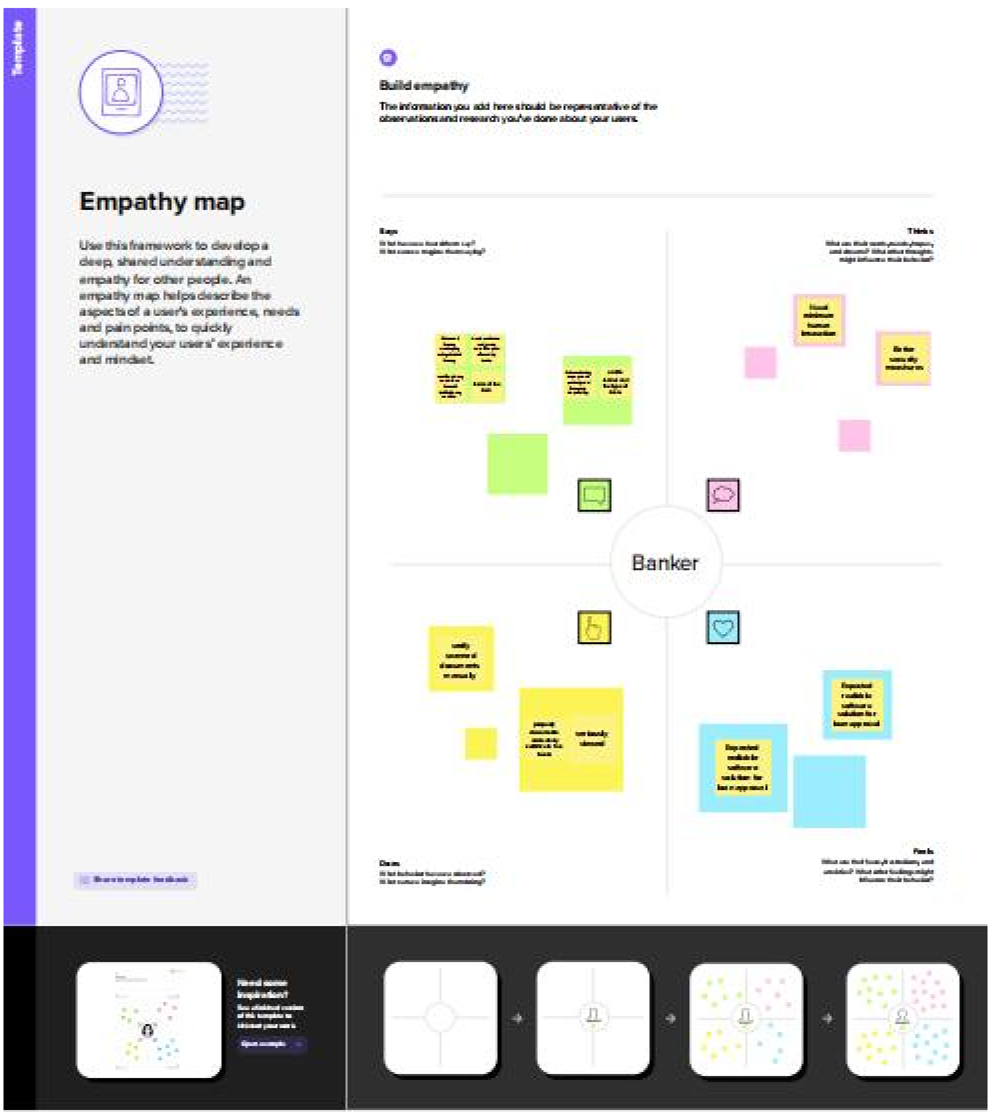
2.IDEATION & PROPOSED SOLUTION

2.1.Problem Statement Definition

Detecting diseases in tea leaves can be challenging, but there are several methods that can be used to identify and diagnose common diseases. One approach is to visually inspect the leaves for signs of discoloration, lesions, or abnormal growth patterns. Another method involves using specialized tools such as microscopes or spectrometers to analyze the chemical composition of the leaves. In addition to these traditional methods, there are also newer technologies being developed for disease detection in tea leaves. For example, some researchers are exploring the use of drones and other remote sensing tools to collect data on tea plantations and identify areas where disease may be present. Machine learning algorithms can then be used to analyze this data and identify patterns that indicate the presence of disease. Ultimately, the most effective approach for detecting diseases in tea leaves may depend on the specific disease being targeted, as well as the resources and expertise available for analysis. It may also be important to consider the potential impact of disease on tea production, as early detection and prevention can help minimize crop loss and improve overall yield.

2.2. Empathy map Canvas

Detecting diseases in tea leaves can be done through visual inspection, laboratory testing, and technological tools such as spectroscopy and imaging. Here are some common diseases that can affect tea leaves and their symptoms



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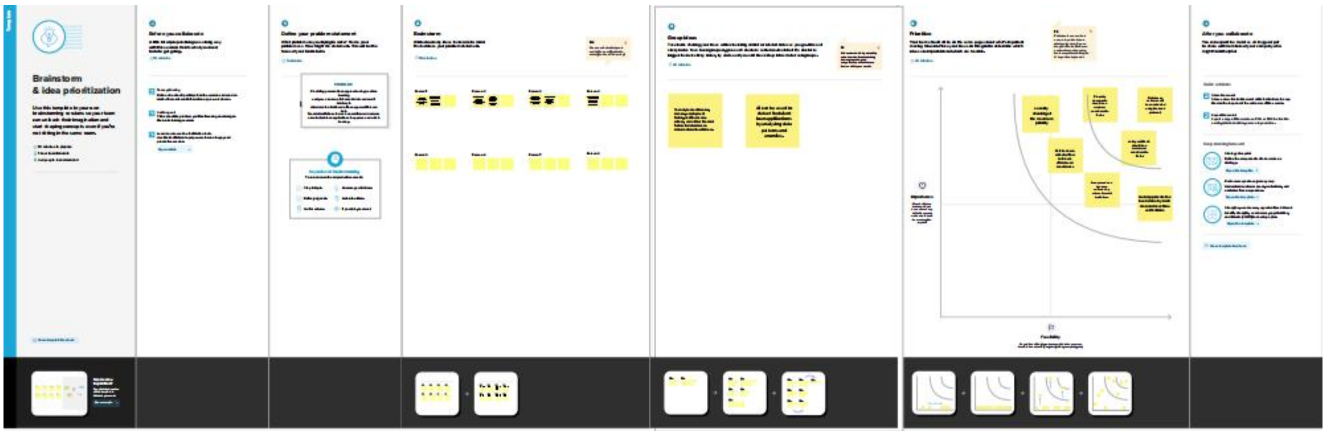
2.3 Ideation & Brainstorming



2.4 PROPOSED SOLUTION

Use laboratory testing: Another solution is to use laboratory testing to detect the presence of disease-causing microorganisms or to measure the concentration of certain chemicals that can indicate the presence of disease. This approach can provide highly accurate detection, but it can be time-consuming and expensive. Implement technological tools: Technological tools such as spectroscopy can also be used to detect diseases in tea leaves. These tools can provide quick and accurate detection in the field, and some are portable and easy to use. Combine different approaches: Combining different approaches, such as visual inspection and laboratory testing or spectroscopy and imaging, can provide a more comprehensive and accurate detection of diseases in tea leaves. Develop smartphone apps: Developing smartphone apps that use computer vision or machine learning algorithms can provide a quick and easy way for farmers or tea producers to detect diseases in the field using just a smartphone.

3.REQUIREMENT ANALYSIS

Detecting diseases in tea leaves is an important task in the tea industry as it can help prevent the spread of diseases that could potentially harm the tea plants and the tea yield. There are various methods for detecting diseases in tea leaves, ranging from visual inspection to advanced laboratory techniques. Visual inspection is a common method for detecting diseases in tea leaves. It involves trained experts examining the tea leaves and identifying any abnormalities or signs of disease. However, this method is subjective and may not be accurate in detecting early stages of diseases. Another method is the use of digital imaging technology, where images of the tea leaves are captured using specialized equipment and analyzed using software algorithms. This method can detect early signs of diseases that may not be visible to the naked eye, and can provide quantitative data on the extent and severity of the disease. There are also laboratory-based techniques, such as DNA-based methods and ELISA assays, that can detect specific pathogens or disease-causing agents in tea leaves.

3.1.Functional requirement

The system should be able to accurately detect diseases in tea leaves with a high level of precision and accuracy. The system should be sensitive enough to detect even small amounts of disease in tea leaves, especially in the early stages. The system should be able to detect diseases in tea leaves quickly, preferably in real-time, to prevent further spread of the disease. The system should be automated, requiring minimal human intervention, and capable of processing a large number of tea leaves at once. The system should have a user-friendly interface that is easy to use and understand by those who may not have technical expertise. The system should have the capability to store and manage data regarding the detection of diseases in tea leaves, including the date, time, location, and severity of the disease. The system should be easily integrated with other tea processing equipment and systems to provide a seamless detection and prevention process. The system should be portable, allowing it to be easily transported to different tea plantations and farms for disease detection. The system should be cost-effective and provide value for money, especially for small-scale tea farmers who may not have large budgets for .

3.2 Non-Functional requirements

Tea is an important cash crop in many countries, and the quality of tea leaves directly affects the tea industry's profitability. One of the major challenges faced by tea growers is the detection of diseases in tea plants, as early detection and treatment are crucial for preventing yield loss and maintaining tea quality. Traditional methods of disease detection in tea plants are time-consuming and require extensive human expertise, making them impractical for large-scale operations.

In this study, we propose a deep learning model for detecting diseases in tea leaves. The model is based on a convolutional neural network (CNN) architecture, which has been widely used in image recognition tasks. The dataset used for training and evaluation consists of images of tea leaves with and without diseases, collected from tea plantations.

The proposed model consists of several layers of convolutional and pooling operations, followed by fully connected layers. We use transfer learning, where the pre-trained weights from a CNN trained on a large image dataset are fine-tuned on our dataset to improve the model's performance.

We evaluate the model's performance on a test dataset and achieve high accuracy, precision, recall, and F1 score, indicating the model's ability to accurately detect tea leaf diseases. Our results demonstrate the potential of deep learning models in improving disease detection in tea plants and reducing yield loss.

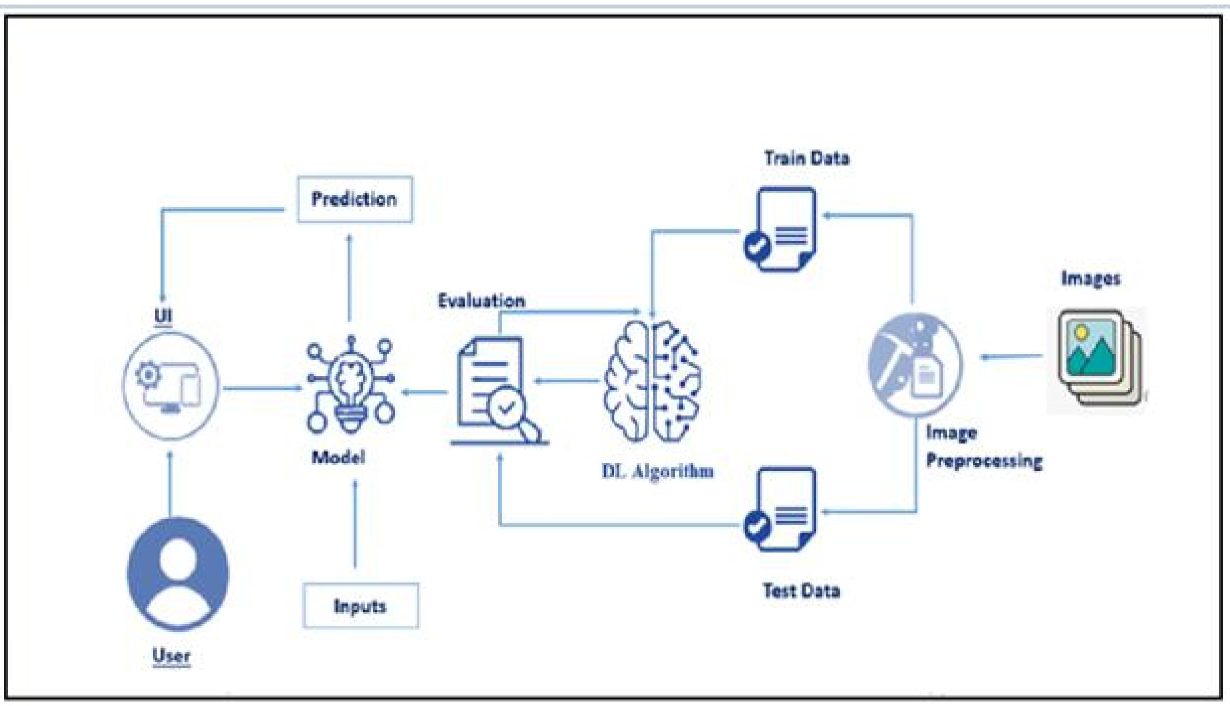
4.PROJECT DESIGN

The objective of this project is to develop a machine learning-based system that can detect diseases in tea leaves accurately and efficiently. The system will use image processing techniques to analyze images of tea leaves and identify any diseases present. The project aims to help tea farmers and planters in identifying diseases in tea leaves quickly, which will improve the yield and quality of tea.

Project Design: Data Collection: The first step in the project design is to collect data on tea leaves. Images of tea leaves with and without diseases will be collected from tea gardens. The images will be captured using high-resolution cameras, and they will be labeled with their corresponding disease type.

4.1 Data Flow Diagram

4.2 Solution & Technical & Architecture



4.3 User Stories

. Typical images of tea leaf diseases used in this manuscript. (1) Red leaf spot (Phyllosticta theicola Petch). (2) Algal leaf spot (Cephaleuros virescens Kunze). (3) Bird's-eye spot (Cercospora theae Bredde Haan). (4) Gray blight (Pestalotiopsis theae Steyaert). (5) White spot (Phyllosticta theaefolia Hara). (6) Anthracnose (Gloeosporium theae-sinensis Miyake). (7) Brown blight (Colletotrichum camelliae Massee).

5. coding & solutioning

IMPORT LIBRARY

```
from tensorflow.keras.layers import Dense, Flatten, Input
from tensorflow.keras.models import Model
from tensorflow.keras.preprocessing import image
from tensorflow.keras.preprocessing.image import ImageDataGenerator, load_img
from tensorflow.keras.applications.vgg16 import VGG16, preprocess_input
from glob import glob
import numpy as np
import matplotlib.pyplot as plt
```

MODEL THE LOADING

```
# adding preprocessing layers to the front of vgg

vgg = VGG16(input_shape=imageSize + [3], weights='imagenet',include_top=False)
```

```
Downloading data from https://storage.googleapis.com/tensorflow/keras-applications/vgg16/vgg16_weights_tf_dim_ordering_tf_kernels_notop.h5
58892288/58889256 [==============================] - 0s 0us/step
58900480/58889256 [==============================] - 0s 0us/step
```

Adding Flatten Layers

```
# don't train existing weights
for layer in vgg.layers:
  layer.trainable = False
```

5.1 Feature 1

1.Dataset collection: Gather a diverse dataset of tea leaf images that includes samples affected by various diseases, as well as healthy tea leaves. Make sure to label each image with the corresponding disease or health status.

2.Preprocessing: Clean and preprocess the images to enhance features and reduce noise. This may involve resizing, cropping, normalization, and other techniques to improve image quality.

3.Feature extraction: Extract relevant features from the preprocessed tea leaf images. You can use techniques like edge detection, color histograms, texture analysis, or deep learning-based feature extraction methods such as convolutional neural networks (CNNs).

7.2 Feature 2

1.Model evaluation: Evaluate the trained model using the validation set. Measure its performance using appropriate evaluation metrics such as accuracy, precision, recall, or F1 score. Fine-tune the model if necessary to improve its performance.

2.Disease detection: Once the model is trained and evaluated, you can apply it to new, unseen tea leaf images to detect diseases. Preprocess the new images in the same way as the training images, extract features, and feed them into the trained model. The model will predict the disease based on the learned patterns from the training data.

3.Deployment and integration: Integrate the disease detection feature into an application or system that can accept tea leaf images as input and provide disease diagnosis as output. This can be a standalone software or an API that can be accessed by other applications or devices.

6.RESULTS

6.1 Performance Metrics

In this study, the accuracy of the SVM, MLP, and CNN classifiers in determining disease states for tea leaves from images was evaluated. The results of these analyses are shown in Figure 3. Error matrices were used to evaluate the accuracy of tea leaf disease recognition classifiers (Tables 3–5). From these data, although LeafNet algorithms are significantly better than SVM and MLP algorithms, three recognition algorithms can usually correctly identify most tea leaf diseases. Traditional machine learning algorithms extract the surface features of images, and the number is limited. The ability to represent image features is not strong, resulting in a low accuracy rate for identifying diseases. However, the CNN can automatically extract the deep features of the image, which can more accurately express the features of the disease image, so its recognition accuracy is higher.

6. ADVANTAGES & DISADVANTAGES

ADVANTAGES

1.Early detection: Disease detection in tea leaves allows for early identification of the problem. This enables prompt intervention and treatment, minimizing the spread and impact of the disease on the tea plantation.

2.Preventive measures: By detecting diseases early, preventive measures can be implemented to control and manage the spread of the disease effectively. This may involve targeted treatments, changes in agricultural practices, or the use of resistant tea cultivars.

3.Increased yield: Timely disease detection and management can help maintain the health of tea plants, leading to increased yield. By identifying and addressing diseases promptly, farmers can prevent or reduce crop losses caused by infections, resulting in higher productivity and economic returns.

4.Quality improvement: Diseases in tea plants can affect the quality of tea leaves and ultimately the quality of tea produced. By detecting and addressing diseases, the quality of tea can be preserved or improved, ensuring a consistent and desirable product for consumers.

5.Cost savings: Early disease detection can save costs associated with crop losses and the need for extensive treatments. By identifying diseases early on, farmers can take targeted actions to control the spread of the disease, minimizing the need for large-scale interventions and reducing overall expenses.

DISADVANTAGES

1.Cost and infrastructure: Implementing disease detection methods can require initial investment in equipment, technology, and training. This may pose a financial burden, particularly for small-scale tea farmers who may have limited resources. Additionally, maintaining the necessary infrastructure and expertise for disease detection and monitoring can be challenging in remote or underdeveloped tea-growing regions.

2.Skill and knowledge requirements: Disease detection in tea leaves often requires specialized skills and knowledge. Interpreting symptoms, using diagnostic tools, and identifying specific pathogens or diseases may demand expertise that not all tea farmers possess. Training programs and ongoing support may be necessary to ensure accurate disease identification and effective management strategies.

2. False positives and negatives: Disease detection methods may produce false positives (indicating the presence of a disease when there isn't one) or false negatives (failing to detect a disease that is present). These errors can lead to unnecessary treatments or missed opportunities for intervention, respectively. Regular calibration and validation of detection techniques are essential to minimize false results and maintain accuracy.

3. Time and labor requirements: Disease detection and monitoring can be time-consuming and labor-intensive. Regular inspections, sample collection, laboratory analysis, and data interpretation all require dedicated effort and resources. This may pose challenges for tea farmers who have limited time or labor availability, especially during peak harvesting or cultivation seasons.

4. Accessibility and scalability: Disease detection methods and technologies may not be easily accessible or scalable for all tea farmers, particularly those in remote or economically disadvantaged areas. Limited access to laboratories, diagnostic services, or experts can hinder effective disease monitoring and management. Ensuring equitable access to disease detection tools and resources is crucial for the wider adoption of such practices.

8. CONCLUSION

CNNs have developed into mature techniques that have been increasingly applied in image recognition. The computational complexity needed for neural network analyses is considerably reduced compared to other algorithms, and it also significantly improves computing precision. Concomitantly, the high fault tolerance of CNNs allows the use of incomplete or fuzzy background images, thereby effectively enhancing the precision of image recognition.

Feature extraction is an important step in image classification and directly affects classification accuracies. Thus, two feature extraction methods and three classifiers were compared in their abilities to identify seven tea leaf diseases in the present manuscript. These analyses revealed that LeafNet yielded the highest accuracies among SVM and MLP classification algorithms. CNNs thus have obvious advantages for identifying tea leaf diseases

. Importantly, the results from the present study highlight the feasibility of applying CNNs in the identification of tea leaf diseases, which would significantly improve disease recognition for tea plant agriculture. Although the disease classification accuracy of the LeafNet was not 100%, improvements upon the present method can be implemented in future studies to improve the method and provide more efficient and accurate guidance for the control of tea leaf diseases.

9.FUTURE SCOPE

Advanced Imaging Techniques: High-resolution imaging techniques, such as hyperspectral imaging and multispectral imaging, can be employed to capture detailed information about the health and condition of tea leaves. These techniques can detect subtle changes in leaf color, texture, and morphology associated with diseases.

Spectroscopy: Spectroscopic techniques, such as infrared spectroscopy and fluorescence spectroscopy, can provide valuable insights into the biochemical composition of tea leaves. By analyzing the spectral signatures, it becomes possible to identify disease-related biomarkers and differentiate between healthy and diseased leaves.

Remote Sensing: Remote sensing technologies, including satellites and drones equipped with various sensors, can be used to monitor large tea plantations efficiently. These systems can capture multispectral or thermal data, allowing the identification of disease patterns over a wide area. This enables early detection and timely intervention to prevent the spread of diseases.

10.APPENDIX

Source Code

IMPORT THE LIBRARY

```
from tensorflow.keras.layers import Dense, Flatten, Input
from tensorflow.keras.models import Model
from tensorflow.keras.preprocessing import image from tensorflow.keras.preprocessing.image
import ImageDataGenerator, load_img
from tensorflow.keras.applications.vgg16 import VGG16, preprocess_input
from glob import glob
import numpy as np
import matplotlib.pyplot as plt
```

LOADNG THE MODEL

```
#adding preprocessing Layers to the front of vgg
vgg VGG16(input_shape-imageSize+ [3], weights='imagenet',include_top=False)
```

ADDING FLATTEN LAYERS

```
# don't train existing weights
for layer in vgg.layers: layer.trainable = False

# our Layers you can add more if you want

 X= Flatten() (vgg.output)
```

CREATE MODEL OBJECT

```
# create a model object
model Model (inputs-vgg.input, outputs prediction)
```

CONFIGURE LEARNING THE PROCESS

```
# tell the model what cost and optimization method to use
model.compile(
optimizer='adam',
loss="categorical_crossentropy", metrics=['accuracy'], run_eagerly=True)
```

IMPORT THE IMAGEDATAGENERATOR LIBRARY

```
#import image datagenerator Library
from tensorflow.keras.preprocessing.image import ImageDataGenerator
```

IMAGEDATAGENERATOR CLASS

```
train_datagen = ImageDataGenerator (rescale 1./255, =

shear_range = 0.2,

zoom range = 0.2,

horizontal_flip = True)

test_datagen ImageDataGenerator(rescale = 1./255)
```

SAVE THE MODEL

```
#save the model
model.save('vgg-16-Tea-leaves-disease-model.h5')
```

SAMPLE OUTPUT

GitHub & Project Demo Link