



Design and implementation of an intelligent Vision-Based Crop Leaf Disease Detection System Using Machine Learning Algorithms

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Abstract— India is a developed nation, yet 70% of the population relies on agriculture. Farmers in India continue to examine the leaves for illnesses using the old-fashioned way. Farmers or specialists use their unaided eye to observe the ailment. This is how leaf diseases are recognised and detected. Farmers must spend a lot of time personally examining the disease. In such a situation, the farmers will benefit from our suggested model's automatic disease detection. The purpose of the proposed study is to create a tool that detects and categorises leaf diseases. To that end, we are creating a smart device that, using machine learning and image processing, can make personalised treatment recommendations for plant diseases based on their symptoms, triggering factors, and fertilisers. This is crucial since it provides audio and spoken information on plant diseases to help the farmer. The suggested method was tested on a wide range of photos featuring rice, tomato, and pepper leaf diseases. To cross-validate the procedure, its effectiveness was tested on cases supplied by Data sets that are already stored for the infected and uninfected instances of leaf disease. The trained model achieves an accuracy of 79.5% on a held-out test set, demonstrating the feasibility of this approach.

Keywords— Leaf disease, Python IDLE 3.8.5, Image Processing, Convolutional Neural Network (CNN).

I. INTRODUCTION

A considerable decrease in both the quality and quantity of agricultural products is caused by plant disease. Research on visually discernible patterns on plants are referred to as plant disease research. In order to successfully cultivate crops on the farm, it is crucial to monitor plant health and disease. The leaf infections may occur due to environmental condition changes such as huge rain fall, drastic changes in temperature or maybe due to improper maintenance and some insects and pesticides [1].

In the beginning, a specialist in that sector would manually monitor and analyse plant illnesses. This involves a huge amount of labour and takes a long time to process. Plant disease detection can be done using image processing techniques [4]. Disease symptoms are typically visible on the fruit, stem, and leaves. The plant leaf, which exhibits disease signs, is taken into consideration for disease detection. The conventional approach of disease detection involves the identification and detection of plant diseases via merely

expert optical observation. Farmers need oversized team of specialists still as continuous watching of specialists are needed, that prices terribly high once farms are massive. However, in some nations, farmers lack the necessary infrastructure.

But in a few nations, farmers lack the necessary resources or even the knowledge that they can consult professionals. Additionally, hiring experts is not only expensive but also time-consuming. The suggested method works well in these circumstances for keeping an eye on vast fields of crops. It is simpler and less expensive to automatically identify diseases based just on their symptoms on plant leaves. In order to enable image-based automatic process control, inspection, and robot guiding, this also supports machine vision. However, using an automatic detection method will require less work, less time, and result in higher accuracy. Brown and yellow spots, early and late scorch, and other common bacterial, viral, and fungal diseases are all present in plants. [10] Image processing is utilised to quantify the disease's afflicted area and pinpoint its location. There are many techniques that are presently being utilized to make computer-based vision systems victimization options of plants extracted from pictures as input parameters to varied classifier systems. During this project a method to argument already existing techniques of plant leaves identification system is represented. This project is a brand-new classification model involving neural networks (NN) was utilized to develop a device primarily based vision system for automatic identification of plant species [8]. The current approach for detecting plant disease is simple naked eye observation by plant experts, which can be used to detect and identify plant diseases. In these circumstances, the suggested technique is useful for tracking vast fields of crops. Furthermore, in some nations, farmers lack adequate facilities or are unaware that they can contact experts. As a result, consulting experts is not only more expensive but also more time consuming. In those circumstances, the suggested technique for tracking a large number of plants would be useful. The most vulnerable component of plants, the leaves, are where disease symptoms first appear. From the very beginning of their life cycle until they are ready to be harvested, the crops must be inspected for illnesses. Initially, specialists manually observed crop fields using the time-consuming method of traditional naked eye surveillance to

keep a check on the plants for illnesses. A variety of strategies have been used in recent years to produce automatic and semi-automatic plant disease detection systems, and automatic disease detection by simply seeing the symptoms on plant leaves makes it simpler and less expensive [11]. As of now, these methods have proven to be quicker, less expensive, and more precise than the conventional approach of manual observation by farmers. Disease symptoms are typically visible on the fruit, stem, and leaves. The plant leaf is taken into consideration for disease identification since it exhibits disease signs. There are numerous instances where farmers lack comprehensive understanding of the crops and the diseases that can impact them [2].

A mobile crop advising app for growers, extension personnel, and gardeners is called Plantix. PEAT, an AI start-up with offices in Berlin, created Plantix. The software makes the claim that it can identify crop-damaging pest infestations, plant diseases, and nutrient deficits and provide appropriate remedial action. Users can engage in the online discussion on plant health issues with scientists, farmers, and other plant experts. Farmers can access local weather, get good agricultural advice throughout the season and receive disease alerts once a disease is spreading in their surroundings.

PlantSnap is an artificial intelligence algorithm requires that you take crisp, clear photos of just a few leaves or a single flower (no whole trees). The algorithm then scans the photo and helps you name your plant in a snap. You can learn more about your plant after PlantSnap identifies it. Works on every continent and has over 500,000 species in the searchable database.

iNaturalist: Artificial intelligence is used here to immediately ID all kinds of plants and wildlife, and it's also a social network for naturalists — you can record and share observations of plants, add them to the database and in turn ask the community for help identifying your finds. iNaturalist is a joint initiative of the California Academy of Sciences and the National Geographic Society.

Leaf Doctor[13] evaluates plant diseases quantitatively using plant organs like leaves. Users gather or provide images of infected plant organs, then compute the proportion of infected tissue. The algorithm uses user-specified values for up to eight colours of healthy tissues in the image when a user touches the device's screen. The state of each pixel's colour is then classified as either healthy or diseased based on how close it is to the healthy colours. Before the percentage computation, users can adjust a threshold bar until they are satisfied that diseased tissues are appropriately represented. Any recipient may receive the assessment data and images via email. The About screen contains the app's usage instructions. The College of Tropical Agriculture and Human Resources at the University of Hawaii at Manoa produced The Leaf Doctor.

Problems in Existing System are

- Only humans are capable of predicting diseases.
- The procedure is extremely slow.
- Consumption of time and space is also very high.
- The price is also high

II. LITERATURE REVIEW

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Pallavi. S. Marathe, proposed a research paper "Plant Disease Detection using Digital Image Processing and GSM". The suggested solution employs GSM to send the pesticide name to the farmer's mobile phone and digital image processing for the purpose of identifying plant

diseases. Image acquisition, image pre-processing, picture segmentation, feature extraction and classification, and transmission are all processes in the disease identification process [1].

H. Rizk and M. K. Habib, have proposed "Robotized Early Plant Health Monitoring System". The integrated robotized online system's testing and results demonstrated its effectiveness in giving crucial plant health information in real time under field settings with an accuracy of 83%. Plant health classification is contrasted with human observation, which distinguishes between healthy and sick plants. Farmers can successfully use a map of plant health locations to identify good and unhealthy areas and take quick, decisive action to assist plants recover. At early stages of plant growth, nutrient-deficient plants can be identified and categorised for controlled nutrient delivery. The robotized system automates plant health monitoring in a cost-effective manner. This approach also allows for selective pesticide application because mapping of sick plants can reveal viral infestations. For automatic water and nutrient irrigation, this system can be linked with a greenhouse nutrient management system [2]. H. Ajra, M. K. Nahar, L. Sarkar and M. S. Islam, have proposed "Disease Detection of Plant Leaf using Image Processing and CNN with Preventive Measures," The topic of grain and vegetable leaf diseases, which is detrimental to farmers in the agricultural sector, has been discussed in this study. Through the use of image processing and CNN, this research has proposed a substantial diagnostic strategy for tomato and potato plant leaf diseases. To explore the signs of a diseased leaf, data pre-processing, augmentation, and data extraction operations are used on Kaggle datasets of potato and tomato leaves [3].

V. Rajesh Kumar, K. Pradeepan, S. Praveen, M. Rohith and V. Vasantha Kumar, has proposed "Identification of Plant Diseases Using Image Processing and Image Recognition," This paper proposes an algorithmic program for the disease detection and categorization with the assistance of machine learning mechanisms and image recognition tools. First detect and record the contaminated area and then perform image pre-processing. Then collect the fragments, identify the infected area, and perform feature extraction on it. This article discusses the methods of using leaf photography to detect plant diseases. In addition, this article also introduces some feature segmentation and extraction algorithms for plant disease detection [4]. S. Veni, R. Anand, D. Mohan and P. Sreevidya, have projected "Leaf Recognition and Disease Detection using Content based Image Retrieval," The proposed method for leaf identification and disease detection in this research was developed with success. This paper provides an example of how to identify, detect, and classify leaf and its illnesses more quickly and accurately. The classification of diseases using SVM and KNN is compared in this work. In this instance, SVM outperformed KNN in terms of accuracy and precision [5].

G. Shrestha, Deepshikha, M. Das and N. Dey, has proposed "Plant Disease Detection Using CNN," The suggested algorithm is successfully used in this research to train the system. With no overfitting, the accuracy rate on the test set is 88.80%. Even though the remaining 12.20% is covered, there is still potential for development. This work can help people track their indoor plants and give farmers a way to maintain tabs on the crop while also advancing the field of agriculture. This research can be worked upon to create an app that would allow one to learn the treatment for a plant illness [6].

Goals and Objectives

In agriculture, where image-based disease identification is crucial, plant disease detection is a topic that receives a lot of interest. The following are the project's goals:

- To develop a system that is capable to detect and identify leaf disease in plant
- Identify the disease faster
- Cost effective

III. SYSTEM DESIGN

Systems design is the process of defining a system's components, including modules, architecture, components, their interfaces, and data, depending on the requirements that have been given. It is the process of defining, creating, and designing systems that meet the unique demands and requirements of an organization or business, as well as the various interfaces at which those components communicate with one another and the data that flows through the system. The purpose of the proposed study is to create a tool that detects and categorizes leaf illnesses. As shown in figure 1, we are creating a tool for plant leaf disease identification utilizing image processing and machine learning.

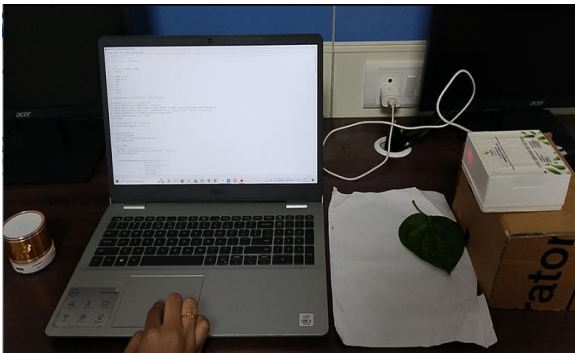


Fig. 1. Working model

There are fundamentally four phases to the plant disease detection system's process, as depicted in figure 2. The first phase involves acquisition of images through mobile phone or from the web camera. Here we use an open CV for capturing images. The second phase is image pre-processing. We use CLAHE (contrast limited adaptive histogram equalization) for image contrast and removing background noise. One of the vital applications of image processing is to identify the image which is a vital tool of early disease detection for growth in crop production. This tool will help to lessen the time and cost consumed during manual prediction. We can infer from the statistics above that our project has a surprising degree of accuracy in identifying diseases. The K-means clustering algorithm is used in the third phase to divide the image into varying numbers of clusters. Methods for feature extraction are in the next phase. It utilises deep learning to compare databases. We use [12] the final stage of CNN categorization involves recognising leaf disease. Then, system design intersects with systems engineering, systems architecture, and systems analysis. In training part of the software, data is an extremely large dataset that is used to teach machine learning model. Training data is used to teach prediction model that use machine learning algorithms we collect the dataset from Kaggle website. Dataset also undergoes following processes: Image pre-processing, image segmentation, image feature extraction. All data are stored in database. It compares with database using deep learning. We use CNN classification for classifying and the last phase is about identifying leaf disease.

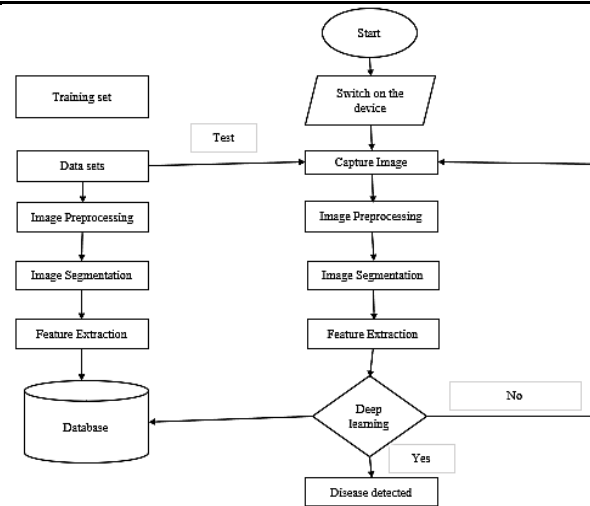


Fig. 2. Leaf Disease detection process

IV. IMPLEMENTATION AND TESTING

A plan, method, concept, idea, model, specification, standard, or policy is implemented when it is carried out, executed, or put into practise. Implementation is therefore the action that must come after any initial planning in order for something to truly occur. Typically, acquiring leaf image data comes first.

LEAF DATASET

The dataset consists approximately 1,584 images of leaf specimens (16 samples each of 99 species) which have been converted to binary black leaves against white backgrounds. Three sets of features are also provided per image: a shape contiguous descriptor, an interior texture histogram, and a fine-scale margin histogram. For each feature, a 64-attribute vector is given per leaf sample. We have considered 3 plants that is rice, pepper and tomato and found out 13 diseases in these plants from the kaggle website as shown in figure 3.

The proposed method was tested on a wide range of photos featuring rice, tomato, and pepper leaf diseases. The approach is created using a small number of photos before being evaluated using a variety of instances and individual photographs. The method can produce results on a single image or on a stack of images to deliver cumulative results. For cross-validation, the method's effectiveness was evaluated using data sets that were already stored for both infected and uninfected cases of leaf disease, as shown in figure 4. The testing code snippet is displayed in figure 5. The training code snippet is displayed in figure 6.

V. RESULTS AND ANALYSIS

In this section we will see the results and analysis of proposed work. Test results on pepper leaf, rice leaf and tomato leaf are tabulated in Table 1, Table 2 and Table 3 respectively. Figure 7 shows the accuracy graph. Above graph shows the accuracy of trained values in accuracy versus epoch's graph.

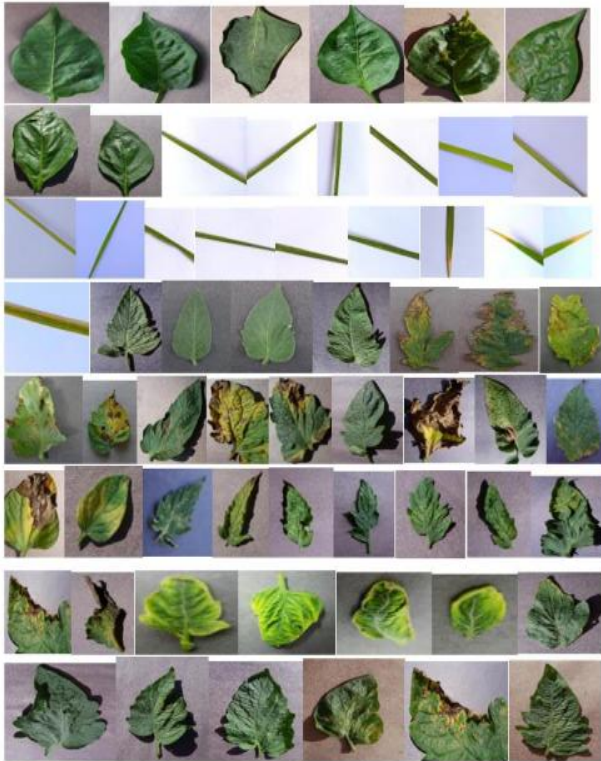


Fig. 3: Leaf Dataset

Fig. 4. Screenshot of Testing Result without user interface

```

import numpy as np
import cv2
from keras.models import load_model
from keras.preprocessing.image import ImageDataGenerator, img_to_array, load_img
import random, os, glob
import matplotlib.pyplot as plt
from keras.preprocessing import image

dir_path = 'D:/project/leafdata'
img_list = glob.glob(os.path.join(dir_path, '**/*.jpg'))
print(len(img_list))

train=ImageDataGenerator(horizontal_flip=True,
                        vertical_flip=True,
                        validation_split=0.1,
                        rescale=1./255,
                        shear_range = 0.1,
                        zoom_range = 0.1,
                        width_shift_range = 0.1,
                        height_shift_range = 0.1,)

test=ImageDataGenerator(rescale=1./255,
                       validation_split=0.1)

train_generator=train.flow_from_directory(dir_path,
                                         target_size=(300,300),
                                         batch_size=32,
                                         class_mode='categorical',
                                         subset='training')

test_generator=test.flow_from_directory(dir_path,
                                       target_size=(300,300),
                                       batch_size=32,
                                       class_mode='categorical',
                                       subset='validation')

labels = (train_generator.class_indices)
labels = dict((v,k) for k,v in labels.items())
    
```

Fig. 5. Testing code

```

import numpy as np
import cv2
from keras.callbacks import ModelCheckpoint, EarlyStopping
from keras.layers import Conv2D, Flatten, MaxPooling2D, Dense, Dropout, SpatialDrop
from keras.models import Sequential
from keras.preprocessing.image import ImageDataGenerator, img_to_array, load_img
import random, os, glob
import matplotlib.pyplot as plt

dir_path = 'D:/project/leafdata'
img_list = glob.glob(os.path.join(dir_path, '**/*.jpg'))
print(len(img_list))

train=ImageDataGenerator(horizontal_flip=True,
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                                         batch_size=32,
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                                         subset='training')

test_generator=test.flow_from_directory(dir_path,
                                       target_size=(300,300),
                                       batch_size=32,
                                       class_mode='categorical',
                                       subset='validation')

labels = (train_generator.class_indices)
print(labels)
    
```

Fig. 6 Train Code

Table 1: Testing Result on Pepper leaf

LEAF DISEASE	IMAGES	EXPECTED RESULT	RESULT OBTAINED	REMARKS
Pepper bacterial spot		Pepper bacterial spot	Pepper bacterial spot	Successful
Pepper healthy		Pepper healthy	Pepper healthy	Successful

Table 2: Testing Result on Rice leaf

Rice brown spot		Rice brown spot	Rice brown spot	Successful
Rice hispa		Rice hispa	Rice hispa	Successful
Rice leaf blast		Rice leaf blast	Rice leaf blast	Successful
Rice healthy		Rice healthy	Rice healthy	Successful

Table 3: Testing Result on Tomato leaf

Tomato early blight		Tomato early blight	Tomato early blight	Successful
Tomato late blight		Tomato late blight	Tomato late blight	Successful
Tomato leaf mould		Tomato leaf mold	Tomato leaf mold	Successful
Tomato mosaic virus		Tomato mosaic virus	Tomato mosaic virus	Successful
Tomato Septoria leaf spot		Tomato Septoria leaf spot	Tomato Septoria leaf spot	Successful
Tomato spider mite		Tomato spider mite	Tomato spider mite	Successful
Tomato yellow leaf curl virus		Tomato yellow leaf curl virus	Tomato yellow leaf curl virus	Successful
Tomato bacterial spot		Tomato bacterial spot	Tomato bacterial spot	Successful
Tomato target spot		Tomato target spot	Tomato target spot	Successful
Tomato healthy		Tomato healthy	Tomato healthy	Successful

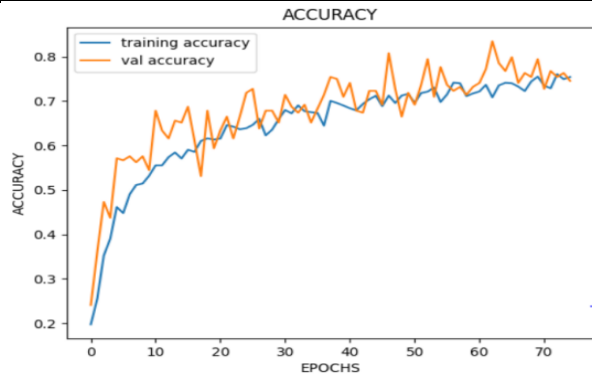


Fig. 7. Accuracy Graph

VI. CONCLUSION

The goal of the project is to create an image-processing-based tool for diagnosing plant leaf disease. Identification of the image that is a crucial tool for early disease diagnosis for growth in agricultural production is one of the essential applications of image processing. The time and money spent on manual prediction will be reduced with the use of this technology. illness detection takes a picture of a leaf and determines whether it is sick or not. The typical manual visual quality inspection cannot be defined systematically since it relies solely on the expert's eyeball observations, which is extremely expensive once farms are large. In addition to the excessive processing times, it also requires a significant level of skill in the field of plant disease diagnoses (phytopathology). As a result, image processing has been used to identify plant illnesses. We can infer from the results that our project offers a surprising degree of accuracy in disease detection. Hardware and software prototyping achieved two goals: validating the proposed architecture and ensuring that the technology used was suitable. This work can be further extended to building a real time application which can identify further plants leaf disease.

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