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Tomato Plant Leaf Disease Detection Using Convolutional Neural Network

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Abstract: Our country is growing country, India is mostly depended on the agriculture field, and Agriculture is pillar of our country's economy. Because of this India has to improve in agriculture filed, in many of situations' farmer face difficulties to detect crop disease in a case large area farm, or late in detection of crop disease in such cases farmer lose their all crop and face the huge loss, to avoid this, in agricultural field is detection of plant diseases is very important. And it is very difficult tasks. In regular normal procedure it requires a more time period and trained person to detect accurate plant disease. In this paper, we proposed effective way for plant disease detection using computer science and machine learning model. Disease transmission from unhealthy plant to all other healthy plants in farm is one of the major damages to crop farm. And these diseases spread like forest fire and have the possible to impact the whole operation if not identified in early on. Now Plant disease detection methods helps to identify infected plants in a very early stage and also help us to identify plant disease in a wide range of area of crops in a cost-effective manner. The aim of this project model is to implement machine learning models, in our proposed system we take a plant leaf image on that leaf images we predict the plant disease using Convolution Neural Networks (CNN) model, in that we build a such a model to predict the plant disease with maximum accuracy and it is for plant disease detection for tomato plant. This machine learning model is analyzing different image metrics pixels data to determine the best performance of network. For that dataset were used around 7around 8016 images we going to use to train the model. We going to use 14 layers CNN models to get better accuracy results. Model consist various layers like convolution, pooling, flatten and dense. Early two layers that is preprocessing and augmentation of images Finally, we get the result of which disease that plant have.

Keywords: CNN, Pooling, Convolution, Classification, Dense, Flatten, Machine learning, Hypermeters

1.Introduction

Agriculture is very important for humans and all living things life. In our traditional system, there is no mechanism to detect diseases on different crops in the agricultural farm that affect the growth of individual species in a farm. With the help of machine learning, we achieve accuracy in this area of research is improving continuously. In India, about 70% of the population is dependent on the agriculture field. Identification of plant diseases is important to prevent crop loss. Identifying plant diseases by hand is extremely slow. It The main goal of machine learning is to understand training data and fit that training data into designed models that should be useful to humans. In such a way, it can help make good decisions and predict the very right results from large amounts of training datasets. Color of Leaf, how many degree of leaf damage, area of leaf, and texture specifications of leaf are used for classification process. We analyzed different image specifications or features to recognize different plant diseases to achieve the more possible accuracy. Ahead of requires a huge amount of work, and expertise in the reorganization of plant diseases and also needs a lot of time. Therefore, image processing and machine learning models can be used to detect plant diseases and it is very beneficial for early detection of plant disease. In this project, we described a technique for detecting plant diseases using leaf images. Image processing is a branch of signal processing that can extract image features or useful information from an image. Machine learning is a branch of artificial intelligence that works automatically or gives instructions to perform a specific task in a model.

time, the detection of plant diseases was done by visual inspection of leaves or chemical processes by experts. This requires a large team of experts as well as constant observation of the plants, resulting in high costs for large farms. Under such conditions, the recommended system proves itself in monitoring large crop fields. Automatic disease detection by simply recognizing symptoms on plant leaves makes it easy and cheap. The proposed system is a solution for plant disease detection is computationally less

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expensive and requires less prediction time than other deep learning approaches because it using statistical machine learning and an image processing algorithm is easier.

Agribusiness has long used modern science to meet the food needs of 7 billion people. However, those involved in agriculture face many threats that threaten the food security of human society. Some of these threats are known as climate change, livestock grazing, plant diseases, etc. Among the many threats, the impact of plant diseases is significant because they not only cause a huge waste of crops for human consumption but also greatly affect the health of human society and the lives of farmers whose main source of income is the production of healthy crops. During harvest, experts must go through a careful process of inspecting and removing mature plants to ensure they are disease-free and fit for human consumption.

However, this traditional visual method of identifying the name of a disease affecting a particular plant is very time-consuming and expensive, especially if the farm is large and there are many plants. Moreover, as the world's population is increasing day by day, it is practical for this process to be automated to meet the growing demands of people. With the advent of machine learning models, early detection of plant diseases has become much easier, less time-consuming, and cheaper compared to traditional visual identification of plant diseases. Much research has been done in this area in recent years, so the industry is slowly moving to replace traditional plant disease identification with machine learning models. The goal of this work is to implement two different machine learning models, namely Convolutional Neural Network (CNN) and K-nearest Neighbor (KNN).

The Necessity of plant disease detection

· 60% of India's population depends on agriculture.

· 70% of India's economy depends on agriculture.

· So there is a need to control the losses caused by plant diseases.

· This is because agricultural productivity is something on which the economy is highly dependent. For this reason, plant disease detection plays an important role in agriculture.

· Therefore, early detection of plant diseases is becoming increasingly important for monitoring plant health to avoid crop losses.

2.Related Work

This section we describe the recent research works related to our project. Here we go through the different techniques of machine learning, leaf disease detection methods.

CNN Architectures

Lqbal H. Surker, Machine Learning: Algorithms, Real-World Applications and Research Directions they present overview of machine learning and their techniques, data analysis and their application [1]

Mohammad Taye, Theoretical Understanding of Convolutional Neural Network: Concepts, Architectures, Applications, Future Directionsthey describes CNN or CONnet Different types structures and their layers [2]

Laith, Jinglam, Review of deep learning: concepts, CNN architectures, challenges, applications, future directions describe the review of deep learning concepts, CNN architectures and their future directions they were discuss in this paper [3]

Data availability

Sharada P. Mohanty, David P. Hughes and Marcels lathe defines, using deep learning concepts and CNN architecture, how chose algorithm methods, Training and Testing dataset methods their divination, epoch, epoch is training iterations of model that we have develop.[1]

Plant Disease review

Vijai, A. K. Misra presents different classification techniques used for plant leaf disease detection like some steps they flow RGB image as input, apply transformation, feature extraction methods, they use ANN Bayes classifier.[1]

Sujatha R., Sravan, Garine they present they flow basic steps for disease detection, they mainly use K-Means algorithm and SVM.[2]

Marwan, Jamal M. they work on MATLAB using CNN and Ann techniques or algorithms they work on different plats different disease, internationally famous and in their country Iraq.[3]

Jatin Arora, Utkarsh, Prerna present Maize leaf diseases classification, they use 100 images per class of disease using deep forest algorithm.[4]

Mohit Agarwal, Abhishek Singh, they define CNN based approach they use pretrained model that is VGG16. Using that VGG16 model they classify 9 classes of tomato disease.[5]

Kowshik B., Savita, Nimosh, define review of various disease classifying methods using DCNN [6]

Alvaro Fuentes, Sook Yoon, Lee they use deep CNN with ROI pooling layer they conducted experiments machine with 4 NVIDIA Titan Y, GPU's, CUDA 9 with live greenhouses plants.[7]

Arun, V.Dhilip, Oona discover 14 layer DCNN model has perform higher classification performance with 132750 images because DCNN model need more images.[8]

Muhammad, Chowdhury, they compare technique within that they found DenseNet201 Was better extracting images feature [9]

3.The Proposed system

In this part, we present the current computer system for identifying plant diseases using plant leaves. In the proposed system Consists of several steps Fig. 1 shows the main

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structure of the system. We proposed a system for plant disease identification based on leaf images. It consists of different plant diseases which are used to check the accuracy of the disease. Using training data, we then train our classifier and the output is then predicted with optimal accuracy. We use convolutional neural network (CNN) which consists of different layers used for prediction. The main objective is to identify plant diseases with the help of image processing.

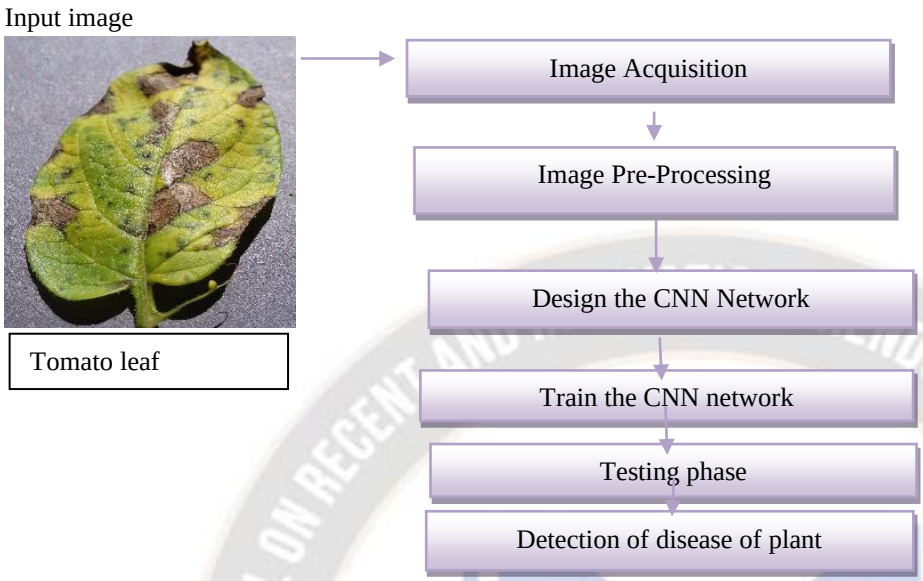

Fig 1. Diagram for plant disease detection

A. Image Acquisition

The first point is: what is an image? An image is represented by its dimensions, that is, height and width, based on the number of pixels. For example, if the dimensions of an image are 500 x 400 (width x height). The total number of pixels in the image is 8000. Image acquisition is the first step required for further processing of the workflow in image processing. Image acquisition can be defined as obtaining a set of image data from sources. This is the most important step in the workflow because an inaccurate image will render the entire workflow useless if the prediction is incorrect.

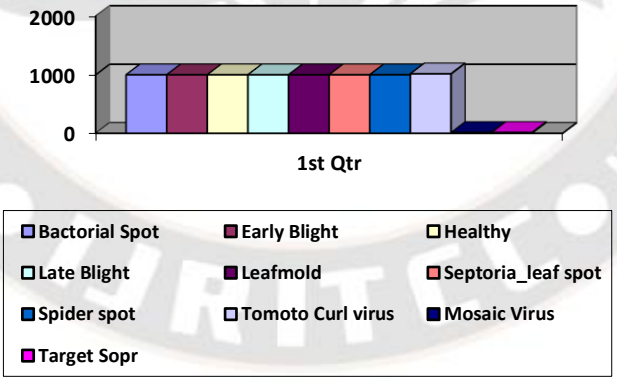

Fig 2. Disease images that been used in dataset for training

B. Image Pre Processing

The purpose of preprocessing is to improve the quality of the image so that we can analyze it better. Preprocessing allows us to remove unwanted distortions and improve certain properties of the image. Preprocessing is necessary to prepare image data for model input. For example, the fully linked layers of foldable neural networks require that all images be in arrays of the same size. Preprocessing the model can reduce the training time of the model and speed up the model inference. If the input images are very large, reducing the size of these images can significantly reduce the time required to train the model without significantly affecting the performance of the model.

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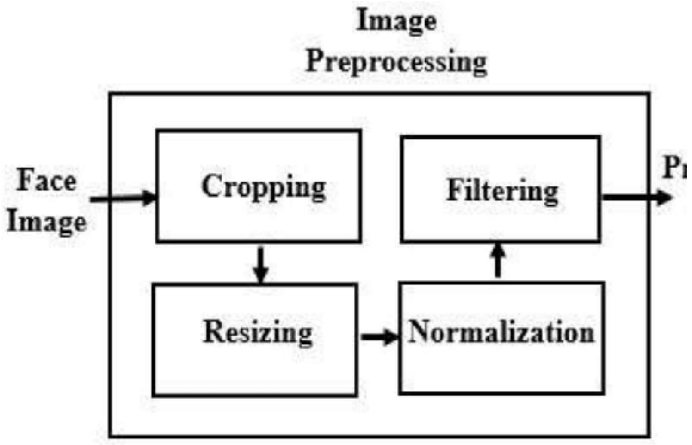

Fig 3: Image Preprocessing

C. CNN Design

Convolutional Neural Network is one of the most important categories for image classification and image recognition in neural networks. Scene labeling, object recognition, face recognition, etc. In these areas where convolutional neural networks are mostly used. CNN takes an image as input, which is classified and processed under a specific category such as dog, cat, lion, tiger, and so on. The computer sees an image as a series of pixels and depends on the resolution of the image. Depending on the resolution of the image, it sees it as h * w * d, where h= height w= width and d= dimension. For example, an RGB image is a 6 * 6 * 3 array of the matrix and a gray scale image is a 4 * 4 * 1 array of the matrix. A CNN consists important three layers an input layer, output layer, convolution layer and pooling layers and hidden layers in between. These layers perform operations that modify the data with the intent of learning specific features of the data.

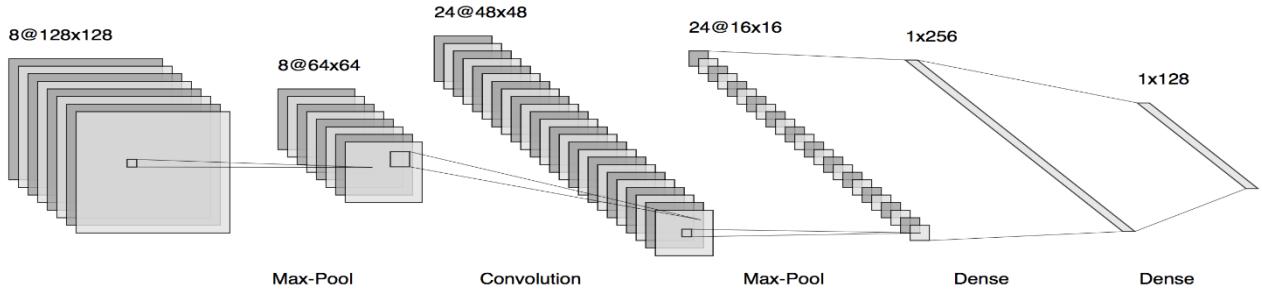

Fig 4.CNN Model Architecture

1.Input Layer

The input layer is the input for the entire CNN. In the image processing neural network, it generally represents the pixel matrix of the image. Each network has a single input layer and a single output layer. The number of neurons in the input layer corelated with to the number of input variables in the data to be processed. The number of neurons in the output layer corresponds to the number of outputs associated with each input

2. Convolution Layer

The convolutional layer is the basic building block of a CNN and is where most of the calculations take place. It requires several components which are input data, filter and object map. Assume that the input is a color image that is made up of a matrix of pixels in 3D. This means that the input will have three dimensions height, width, and depth that correspond to the RGB in the image. We also have a feature detector, also known as a kernel or filter, which will move through the receptive fields of the image and check if a feature is present. This process is known as convolution.

A convolutional layer transforms the input image to extract features from it. In this transformation, the image is convolved with a filter. A kernel is a small matrix whose height and width are smaller than the image to be convolved. It is also known as convolution matrix or convolution mask.

3. Pooling

The Pooling Layer main purpose of this layer is to gradually reduce the spatial size of the image that we want to take as a input for model to reduce the number of computations in the network. Pooling performs down sampling by reducing the size of image and sends only the important featured data to the next CNN model layers. How does convolution differ from pooling? Important variance is that the convolutional layer take out the elements from the data matrix of image, while the pooling layer only resamples the data matrix of image.

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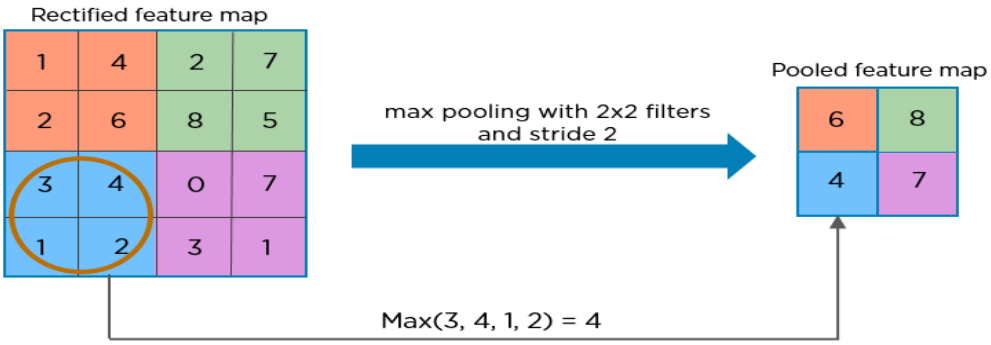

Fig 5. Pooling layer

4.Flatten Layer

Flatten layer is used to compress all the data of images, all the results of 2-Dimensional arrays values from pooling layer s into a single long continuous linear vector array. The goal of flatten layer is make single dimensional array and, commonly for transform last convolution layer output to the full connected layer for the next prediction

5.Dense Layer

Dense Layer is very simple layer of CNN, in this layer each neuron receives input from all previous layer, Dense Layer is used to classify image based on output of convolutional layers. Work of single neuron is holding the values of model and prediction is done on these values from which class the particular image is.

4.Experiment and Result

In this section provides all knowledge about the complete architecture and model creation training accuracy of proposed model for this experiment.

a. Requirements

- Google Colab IDE
- PyCharm IDE
- Computer system with minimum 8GB RAM.

When model developing starts images in dataset is different in numbers in classes to solve this problem image augmentation is used to same out the count of images in classes. Augmentation is technique reduce the overfitting data in dataset images. The image augmentation process flipping, cropping, scaling, rotation are uses creating augmentation images. The layered structure of proposed model shown below figure. the designing of the model it depends on the accuracy rate of result what you get after training, then decide how many conv, and pool layers required for the desire dataset. The same unique values we apply for the model training that we called as hyperparameter. these parameters we can select our own just like how many epochs we want take to train your model below table shows the common parameter we have use in this project.

Table 2. Common Hyperparameter

Hyperparameter	**Value**
Batch Size	**32**
Image Size	**256**
Channels	**3**
Epochs	**50**

b. Dataset

Dataset is collection of images that includes diseased and healthy leaf's of tomato plant. That is collected from various open repositories.one plant was used for this proposed system, in the dataset various classified disease images are present in floders.in whole dataset total 8 classes and total 8016 images in dataset. these 10 classes are namely given below table.

Table 1. List of classes

Plant Name	**Classes**
Tomato	Healthy
	Late_blight
	Early_blight
	Curlvirus
	Leafmold
	Septoria lspot
	Bacterial spot
	Sipder spot
	Target spot
	Mosaic virus

The layered model description in proposed system is below

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Layer (type)	Output Shape	Param #
sequential (Sequential)	(32, 256, 256, 3)	0
sequential_1 (Sequential)	(32, 256, 256, 3)	0
conv2d (Conv2D)	(32, 254, 254, 32)	896
max_pooling2d (MaxPooling2D)	(32, 127, 127, 32)	0
conv2d_1 (Conv2D)	(32, 125, 125, 64)	18496
max_pooling2d_1 (MaxPooling2D)	(32, 62, 62, 64)	0
conv2d_2 (Conv2D)	(32, 60, 60, 64)	36928
max_pooling2d_2 (MaxPooling2D)	(32, 30, 30, 64)	0
conv2d_3 (Conv2D)	(32, 28, 28, 64)	36928
max_pooling2d_3 (MaxPooling2D)	(32, 14, 14, 64)	0
conv2d_4 (Conv2D)	(32, 12, 12, 64)	36928
max_pooling2d_4 (MaxPooling2D)	(32, 6, 6, 64)	0
conv2d_5 (Conv2D)	(32, 4, 4, 64)	36928
max_pooling2d_5 (MaxPooling2D)	(32, 2, 2, 64)	0
flatten (Flatten)	(32, 256)	0
dense (Dense)	(32, 9)	2313

Fig 6.Layerd structure of Our CNN model

c.Model Training

In this proposed system 14 layered CNN model is trained using hyperparameters in google colab gpu enviroment.this model is trained in 50 epochs. We used 80% images around in 8016 used for trainings 20% for testing in that again we divide 10% test and validation each. Maximum number of epochs where decreased the image loss percentage.in this model we use 6 convolution, 6 pooling, 1 Flatten, 1Dense layer. We pass the input as a 32 image batch size,256*256 size image and 3 channels for (R,G,B) colors. For identification of tomato leaf disease.

This 14 layer model is achieve 93% accuracy validation accuracy 90% and loss is 0.28% this proposed model require GPU environment for training process. Finally we plot the accuracy charts for loss and validation

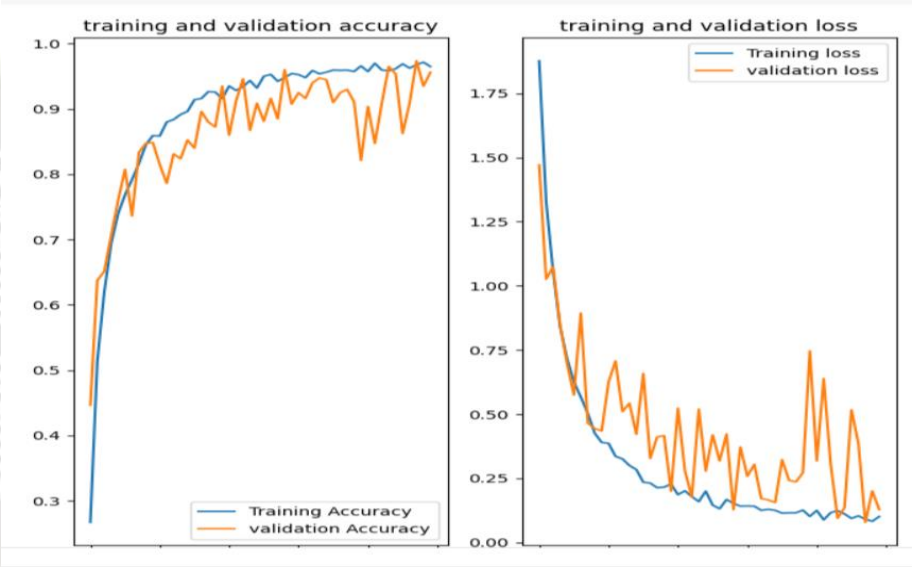
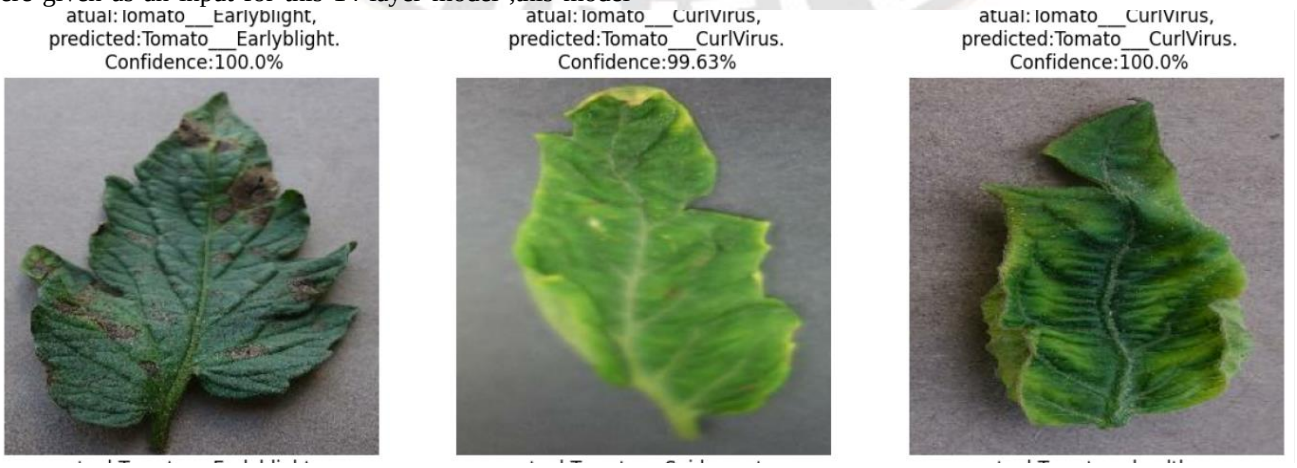


Fig 7.Trainning Accuracy,Validation,Loss of proposed system

d.Model result of prediction

In the saved model we first take shuffled one image from test dataset and take a prediction on it.the images of plant leaf were given as an input for this 14 layer model ,this model successfully predicted the plant disease of tomato leaf in that for vusulization the prediction matplotlib.pyplot library where used for visulization. Images are given below.



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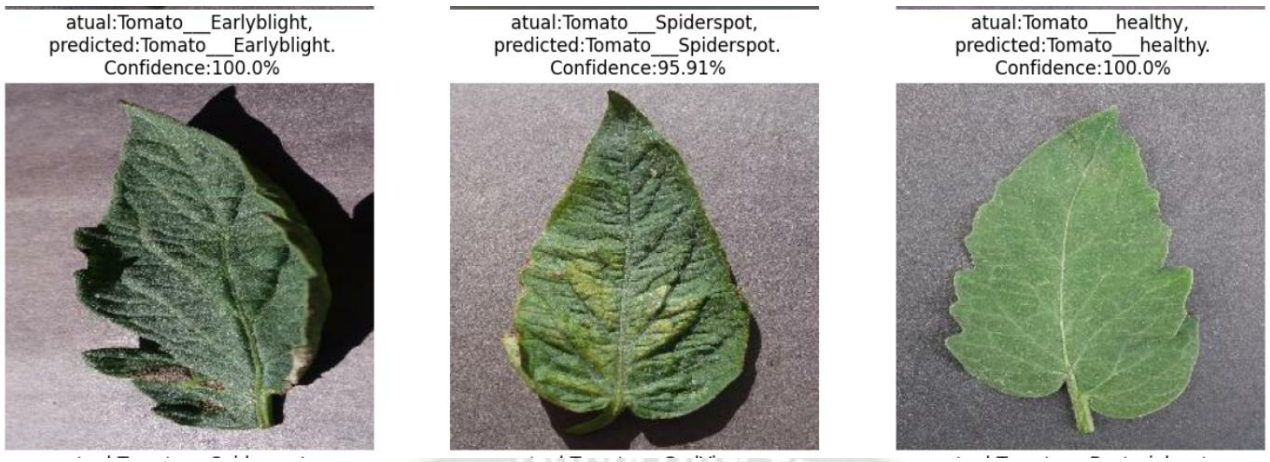

Fig 8.Predicted sample leaf images for this 14 layer model.

Finally we convert this model in h5 file model using tensorflow converter method for making website for tomato disease prediction.this h5 is compressed light weight model used for web application.main use of this application it is simple to use we gave two option you can take picture and predict the disease of tomato disease.below some picture of website with different disease

.

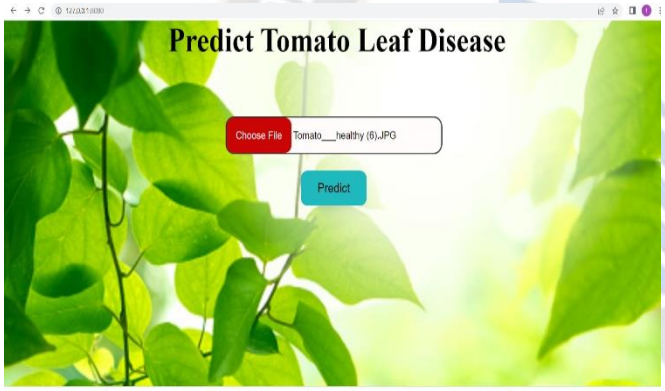

Fig 9 Main page of website

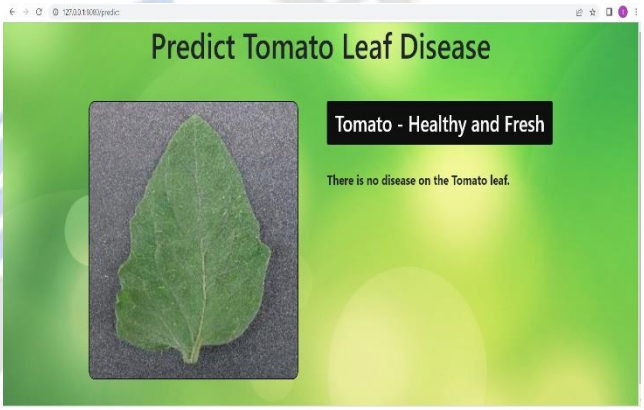

Fig 10 shows the leaf is helthy when we choose healthy leaf

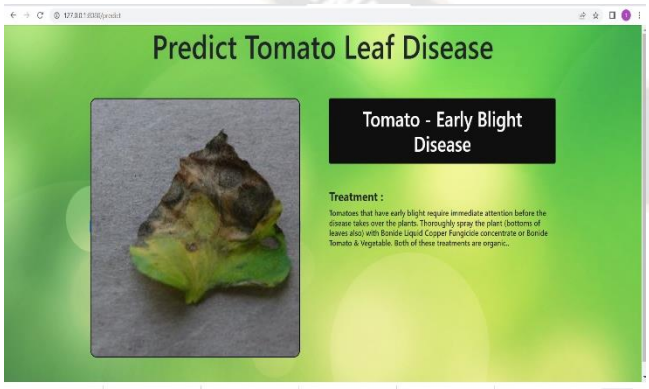

Fig 11 shows the leaf has early blight diasease when we choose arly blight diaseased leaf

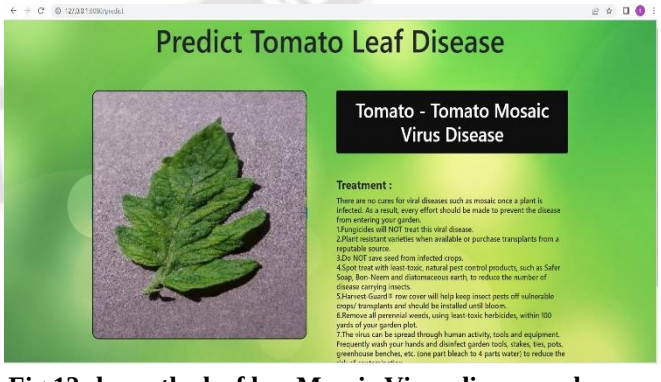

Fig 12 shows the leaf has Mosaic Virus diasease when we choose Mosaic Virus

In this website we cteate templates files for each diasese ,in that we mention the how to get cure from those dissease of tomato plants.

4.Conclusion

This paper presents a various disease prediction of tomato plant. From the tomato plant leaf's this study of in machine learning in this project various methods are used for detection. We use 14-layer CNN model, in that five-convolution layer, five pooling layers, one dense and one flatten layer. This algorithm may be used to increase recognition rates in the classification. Increase recognition rates using more layers and flatten, dense layer. After training this model, over on 8044 images. We got accuracy 96% with 8044 train images. then we convert this trained model in TensorFlow lite model. Load this machine learning model in website and predict the correct disease with more accuracy. Likewise, we can use these AI based models in various application that people can use them easily.

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