MANGO DISEASE DETECTION USING GAN

ABSTRACT

Mango disease prediction is crucial for ensuring healthy yields and maintaining the quality of mango produce. Traditional methods of disease detection in mangoes often rely on manual inspection, which is time-consuming and prone to human error. To address these challenges, this project proposes a novel approach using Generative Adversarial Networks (GANs) to enhance detection accuracy. GANs generate high-quality synthetic images of diseased mangoes, improving robustness and accuracy. The system includes a generator that creates synthetic images and a discriminator that distinguishes between real and synthetic images, augmenting the dataset with diverse disease manifestations. A Convolutional Neural Network (CNN)-based classifier is trained on this enhanced dataset to identify diseases such as anthracnose, powdery mildew, and bacterial black spot with high precision. Experimental results demonstrate a significant reduction in false positives and negatives, showcasing the potential of GANs in improving agricultural disease detection. This approach not only enhances the quality and yield of mango production but also offers a scalable model for various crops and diseases, highlighting the revolutionary potential of GANs in agricultural applications.

Data Set : https://www.kaggle.com/datasets/warcoder/mangofruitdds?resource=download

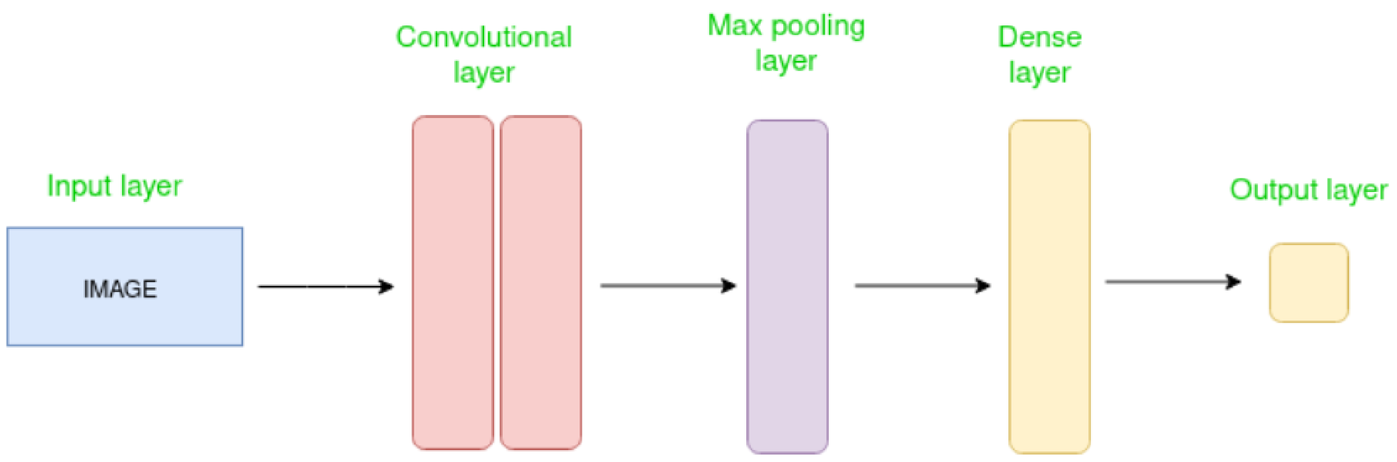
MANGO DISEASE DETECTION USING CNN

CONVOLUTIONAL NEURAL NETWORK (CNN)

A Convolutional Neural Network (CNN) is a type of Deep Learning neural network architecture commonly used in Computer Vision. Convolutional Neural Network (CNN) is the extended version of artificial neural networks (ANN) which is predominantly used to extract the feature from the grid-like matrix dataset. For example visual datasets like images or videos where data patterns play an extensive role.

CNN architecture

Convolutional Neural Network consists of multiple layers like the input layer, Convolutional layer, Pooling layer, and fully connected layers.



Layers used to build ConvNets

A complete Convolution Neural Networks architecture is also known as covnets. A covnets is a sequence of layers, and every layer transforms one volume to another through a differentiable function.

Types of layers: datasets

- **Input Layers**: It's the layer in which we give input to our model. In CNN, Generally, the input will be an image or a sequence of images. This layer holds the raw input of the image with width 32, height 32, and depth 3.
- **Convolutional Layers**: This is the layer, which is used to extract the feature from the input dataset. It applies a set of learnable filters known as the kernels to the input images. The filters/kernels are smaller matrices usually 2×2, 3×3, or 5×5 shape. it slides over the input image data and computes the dot product between kernel weight and the corresponding input image patch. The output of this layer is referred as feature maps.
- **Activation Layer**: By adding an activation function to the output of the preceding layer, activation layers add nonlinearity to the network. it will apply an element-wise activation function to the output of the convolution layer. Some common activation functions are RELU: max(0, x), Tanh, Leaky RELU, etc. The volume remains unchanged hence output volume will have dimensions 32 x 32 x 12.
- **Pooling layer**: This layer is periodically inserted in the covnets and its main function is to reduce the size of volume which makes the computation fast reduces memory and also prevents overfitting. Two common types of pooling layers are max pooling and average pooling. If we use a max pool with 2 x 2 filters and stride 2, the resultant volume will be of dimension 16x16x12.
- **Flattening**: The resulting feature maps are flattened into a one-dimensional vector after the convolution and pooling layers so they can be passed into a completely linked layer for categorization or regression.
- **Fully Connected Layers**: It takes the input from the previous layer and computes the final classification or regression task.
- **Output Layer**: The output from the fully connected layers is then fed into a logistic function for classification tasks like sigmoid or softmax which converts the output of each class into the probability score of each class.

Step:

- Import the Necessary Libraries
- Set the Parameter
- Define The Kernel
- Load the Image and Plot it.
- Reformat the Image
- Apply Convolution Layer Operation and Plot the Output Image.
- Apply Activation Layer Operation and Plot the Output Image.
- Apply Pooling Layer Operation and Plot the Output Image.

MODULE 1 : IMPORTING LIBRARIES AND EXTRACTING LIBRARIES

```
import os
import sys
from tempfile import NamedTemporaryFile
from urllib.request import urlopen
from urllib.parse import unquote, urlparse
from urllib.error import HTTPError
from zipfile import ZipFile
import tarfile
import shutil

CHUNK_SIZE = 40960
DATA_SOURCE_MAPPING = 'mangofruitdds:https%3A%2F%2Fstorage.googleapis.com%2Fkaggle-
data-sets%2F3723789%2F6450350%2Fbundle%2Farchive.zip%3FX-Goog-Algorithm%3DGOOG4-
RSA-SHA256%26X-Goog-Credential%3Dgcp-kaggle-com%2540kaggle-
161607.iam.gserviceaccount.com%252F20240728%252Fauto%252Fstorage%252Fgoog4_request%
26X-Goog-Date%3D20240728T041500Z%26X-Goog-Expires%3D259200%26X-Goog-
SignedHeaders%3Dhost%26X-Goog-
Signature%3Db6d2b3a87ad4665038f0fb681fa4dc41dd46019e17f6920e63829dc3c290ea6d712ddf3
5513cc9b8c90bb82a2b64c8ff140a1ece6d937877fab1be163be15bd9d80c62c9faa7b2c1eec67a461b
6d9c281d720212e2052658baaf3fcc53e21c0255c0513725e3388a17c145b61c8afe9c397c15e6617e2
9d6a0ade1f81a50de272d74b338f4d412a3951ecd9e692e36bf874a7f98ff3f10bcfc4216fd374f15f8
2cdf344dd30555c1c147f419ef55092536a429708b3d500b78cee733078ae1afcf2769518ebead2815b
ca2316e22fb4a683a51d733095daea61bbea4726ddeaa7dfb34925642453313a32e9f2078f9c37b8d05
c7ccafab3919d7d20ff338f730'

KAGGLE_INPUT_PATH='/kaggle/input'
KAGGLE_WORKING_PATH='/kaggle/working'
KAGGLE_SYMLINK='kaggle'

!umount /kaggle/input/ 2> /dev/null
shutil.rmtree('/kaggle/input', ignore_errors=True)
os.makedirs(KAGGLE_INPUT_PATH, 0o777, exist_ok=True)
os.makedirs(KAGGLE_WORKING_PATH, 0o777, exist_ok=True)

try:
 os.symlink(KAGGLE_INPUT_PATH,os.path.join("..",'input'),target_is_directory=True)
except FileExistsError:
  pass
try:
 os.symlink(KAGGLE_WORKING_PATH,os.path.join("..",'work'),target_is_directory=True)
except FileExistsError:
  pass


for data_source_mapping in DATA_SOURCE_MAPPING.split(','):
    directory, download_url_encoded = data_source_mapping.split(':')
    download_url = unquote(download_url_encoded)
    filename = urlparse(download_url).path
    destination_path = os.path.join(KAGGLE_INPUT_PATH, directory)
    try:
        with urlopen(download_url) as fileres, NamedTemporaryFile() as tfile:
            total_length = fileres.headers['content-length']
            print(f'Downloading {directory}, {total_length} bytes compressed')
            dl = 0
            data = fileres.read(CHUNK_SIZE)
            while len(data) > 0:
             dl += len(data)
             tfile.write(data)
             done = int(50 * dl / int(total_length))
             sys.stdout.write(f"\r[{'='*done}{''*(50-done)}]{dl}bytes downloaded")
             sys.stdout.flush()
             data = fileres.read(CHUNK_SIZE)
            if filename.endswith('.zip'):
              with ZipFile(tfile) as zfile:
                zfile.extractall(destination_path)
            else:
              with tarfile.open(tfile.name) as tarfile:
                tarfile.extractall(destination_path)
            print(f'\nDownloaded and uncompressed: {directory}')
    except HTTPError as e:
        print(f'Failed to load{download_url} to path {destination_path}')
        continue
    except OSError as e:
        print(f'Failed to load {download_url} to path {destination_path}')
        continue
print('Data source import complete.')
```

MODULE 2 SPECIFYING AND SPLITTING INPUT PATH

```
import numpy as np
import pandas as pd
import os
for dirname, _, filenames in os.walk('/kaggle/input'):
    for filename in filenames:
        print(os.path.join(dirname, filename))
a_dir = os.path.join('/kaggle/input/mangofruitdds/MangoFruitDDS/
                      SenMangoFruitDDS_original  /Alternaria')
b_dir = os.path.join('/kaggle/input/mangofruitdds/MangoFruitDDS/
                      SenMangoFruitDDS_original/Anthracnose')
c_dir = os.path.join('/kaggle/input/mangofruitdds/MangoFruitDDS/
                      SenMangoFruitDDS_original/Black Mould Rot')
d_dir = os.path.join('/kaggle/input/mangofruitdds/MangoFruitDDS/
                      SenMangoFruitDDS_original/Healthy')
e_dir = os.path.join('/kaggle/input/mangofruitdds/MangoFruitDDS/
                      SenMangoFruitDDS_original/Stem end Rot')
a_names = os.listdir(a_dir)
print(a_names[:10])
b_names = os.listdir(b_dir)
print(b_names[:10])
c_names = os.listdir(c_dir)
print(c_names[:10])
d_names = os.listdir(d_dir)
print(d_names[:10])
e_names = os.listdir(e_dir)
print(e_names[:10])
```

```python
print('total Alternaria images:', len(os.listdir(a_dir)))
print('total Anthracnose images:', len(os.listdir(b_dir)))
print('total Black Mould Rot images:', len(os.listdir(c_dir)))
print('total Healthy images:', len(os.listdir(a_dir)))
print('total Stem end Rot images:', len(os.listdir(a_dir)))
```

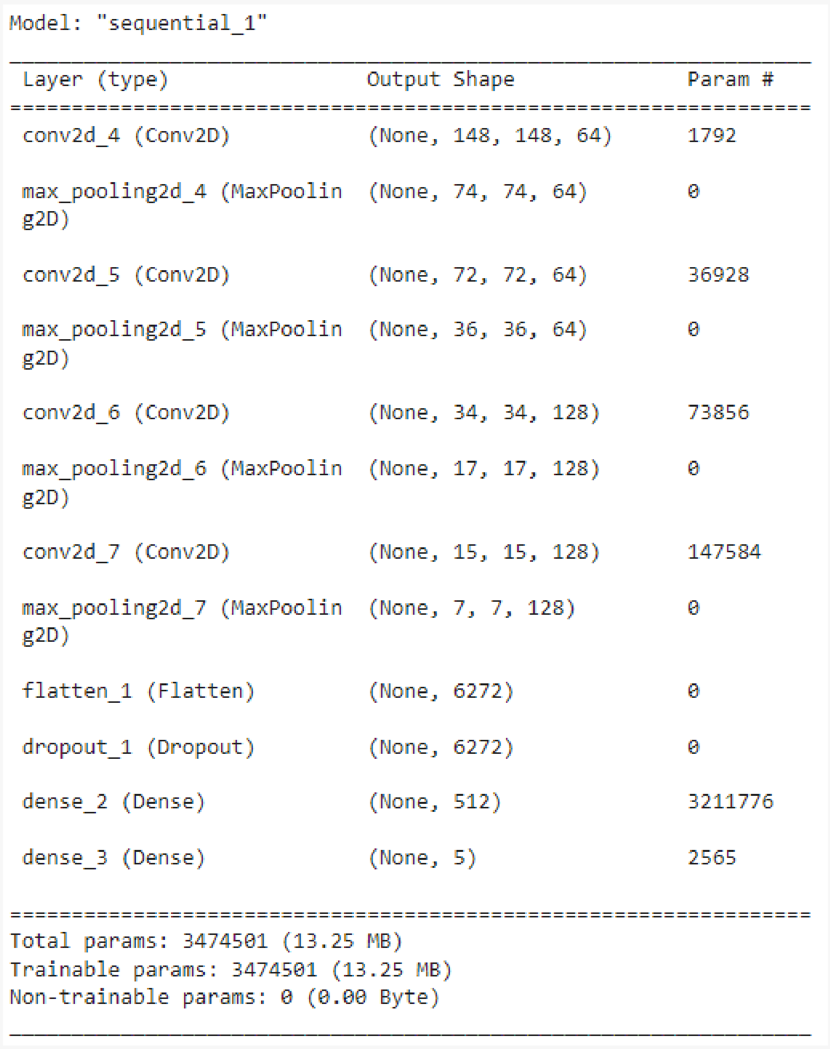
```
total Alternaria images: 170
total Anthracnose images: 132
total Black Mould Rot images: 186
total Healthy images: 170
total Stem end Rot images: 170
```

```python
%matplotlib inline
import matplotlib.pyplot as plt
import matplotlib.image as mpimg
# Parameters for our graph; we'll output images in a 4x4 configuration
nrows = 10
ncols = 4
# Index for iterating over images
pic_index = 0
# Set up matplotlib fig, and size it to fit 4x4 pics
fig = plt.gcf()
fig.set_size_inches(ncols * 4, nrows * 4)
pic_index += 8
a_pix = [os.path.join(a_dir, fname)
                for fname in a_names[pic_index-8:pic_index]]
b_pix = [os.path.join(b_dir, fname)
                for fname in b_names[pic_index-8:pic_index]]
c_pix = [os.path.join(c_dir, fname)
                for fname in c_names[pic_index-8:pic_index]]
d_pix = [os.path.join(d_dir, fname)
                for fname in d_names[pic_index-8:pic_index]]
e_pix = [os.path.join(e_dir, fname)
                for fname in e_names[pic_index-8:pic_index]]
for i, img_path in enumerate(a_pix + b_pix + c_pix + d_pix + e_pix):
  sp = plt.subplot(nrows, ncols, (i % (nrows * ncols)) + 1)
  sp.axis('Off')
  img = mpimg.imread(img_path)
  plt.imshow(img)
```

```
from sklearn.model_selection import train_test_split
data_dir = '/kaggle/input/mangofruitdds/MangoFruitDDS/SenMangoFruitDDS_original'
batch_size = 64
epochs = 30
input_shape = (300, 300, 3)
image_paths = []
labels = []
for category in os.listdir(data_dir):
    category_dir = os.path.join(data_dir, category)
    if os.path.isdir(category_dir):
        for image_filename in os.listdir(category_dir):
            if image_filename.endswith('.jpg'):
                image_path = os.path.join(category_dir, image_filename)
                image_paths.append(image_path)
                labels.append(category)
train_image_paths, test_image_paths, train_labels, test_labels = train_test_split
                              (image_paths, labels, test_size=0.2, random_state=42)
len(train_image_paths),len(test_image_paths), len(train_labels), len(test_labels)
```

```
(689, 173, 689, 173)
```

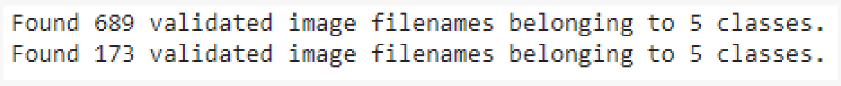
```
import tensorflow as tf

model = tf.keras.models.Sequential([
    tf.keras.layers.Conv2D(64, (3,3), activation='relu', input_shape=(150, 150,
3)),
    tf.keras.layers.MaxPooling2D(2, 2),
    tf.keras.layers.Conv2D(64, (3,3), activation='relu'),
    tf.keras.layers.MaxPooling2D(2,2),
    tf.keras.layers.Conv2D(128, (3,3), activation='relu'),
    tf.keras.layers.MaxPooling2D(2,2),
    tf.keras.layers.Conv2D(128, (3,3), activation='relu'),
    tf.keras.layers.MaxPooling2D(2,2),
    tf.keras.layers.Flatten(),
    tf.keras.layers.Dropout(0.5),
    tf.keras.layers.Dense(512, activation='relu'),
    tf.keras.layers.Dense(5, activation='softmax')
])
model.summary()
```



```
Model: "sequential_1"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 conv2d_4 (Conv2D)           (None, 148, 148, 64)      1792

 max_pooling2d_4 (MaxPoolin  (None, 74, 74, 64)        0
 g2D)

 conv2d_5 (Conv2D)           (None, 72, 72, 64)        36928

 max_pooling2d_5 (MaxPoolin  (None, 36, 36, 64)        0
 g2D)

 conv2d_6 (Conv2D)           (None, 34, 34, 128)       73856

 max_pooling2d_6 (MaxPoolin  (None, 17, 17, 128)       0
 g2D)

 conv2d_7 (Conv2D)           (None, 15, 15, 128)       147584

 max_pooling2d_7 (MaxPoolin  (None, 7, 7, 128)         0
 g2D)

 flatten_1 (Flatten)         (None, 6272)              0

 dropout_1 (Dropout)         (None, 6272)              0

 dense_2 (Dense)             (None, 512)               3211776

 dense_3 (Dense)             (None, 5)                 2565

=================================================================
Total params: 3474501 (13.25 MB)
Trainable params: 3474501 (13.25 MB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
```

```
from tensorflow.keras.optimizers import RMSprop

model.compile(loss='categorical_crossentropy',
              optimizer=RMSprop(learning_rate=0.001),
              metrics=['accuracy'])
from tensorflow.keras.preprocessing.image import ImageDataGenerator
training_datagen = ImageDataGenerator(
      rescale = 1./255,
      rotation_range=40,
      width_shift_range=0.2,
      height_shift_range=0.2,
      shear_range=0.2,
      zoom_range=0.2,
      horizontal_flip=True,
      fill_mode='nearest')
validation_datagen = ImageDataGenerator(rescale = 1./255)
train_generator = training_datagen.flow_from_dataframe(
    pd.DataFrame({'image_path': train_image_paths, 'label': train_labels}),
    x_col='image_path',
    y_col='label',
    target_size=(150,150),
    batch_size=64,
    class_mode='categorical'
)
```

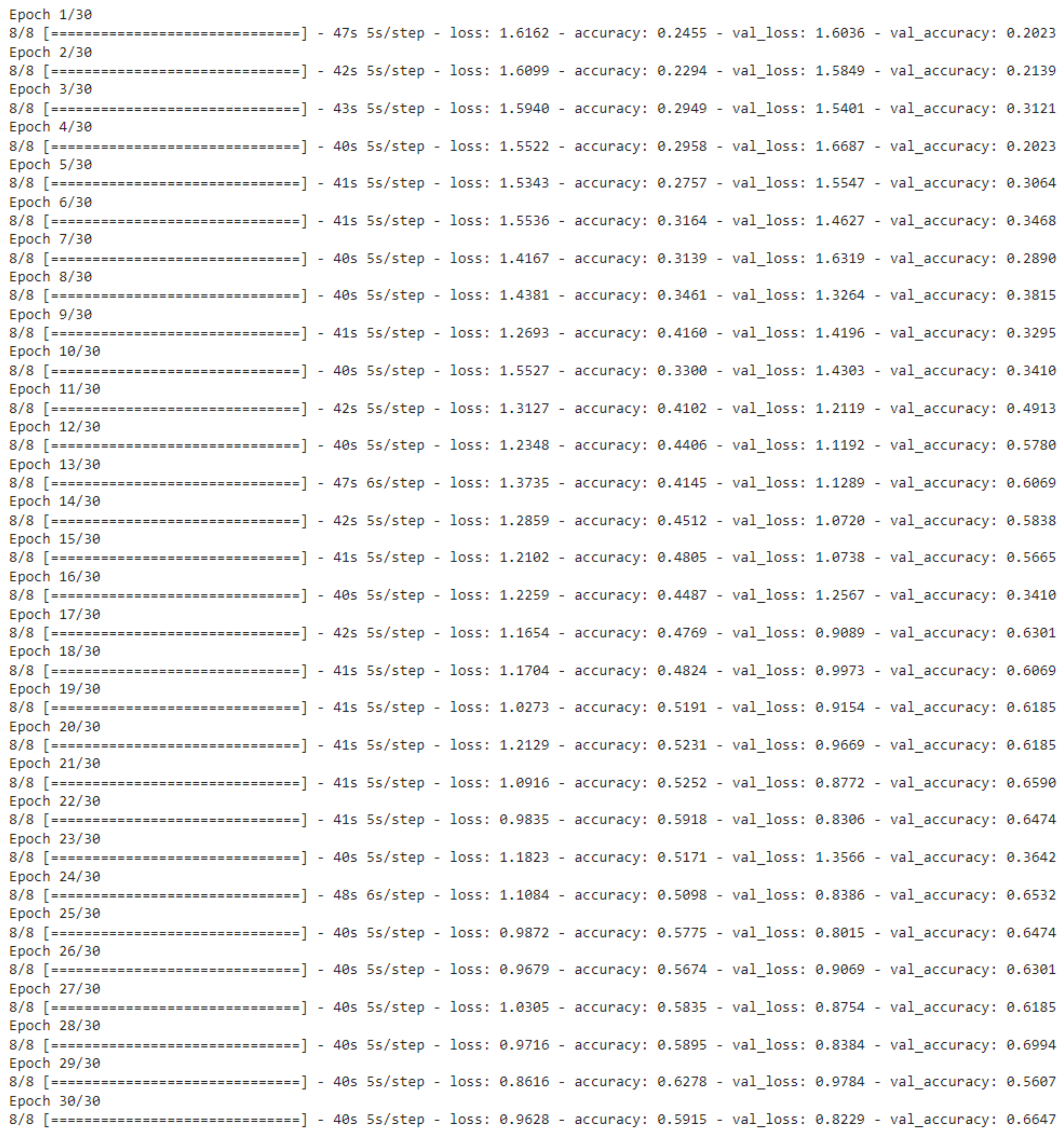
```
validation_generator = validation_datagen.flow_from_dataframe(
    pd.DataFrame({'image_path': test_image_paths, 'label': test_labels}),
    x_col='image_path',
    y_col='label',
    target_size=(150,150),
    batch_size=64,
    class_mode='categorical'
)
```



```
Found 689 validated image filenames belonging to 5 classes.
Found 173 validated image filenames belonging to 5 classes.
```

CALCULATING LOSS AND ACCURACY

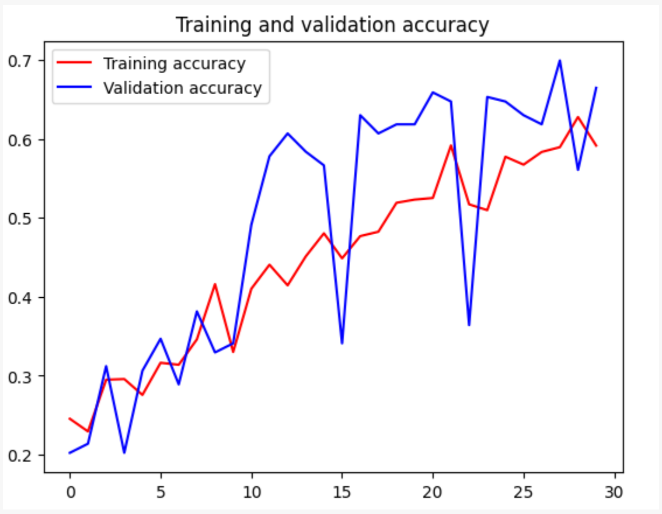
```
history = model.fit(train_generator, epochs=30, steps_per_epoch=8, validation_data
= validation_generator, verbose = 1, validation_steps=3)
```

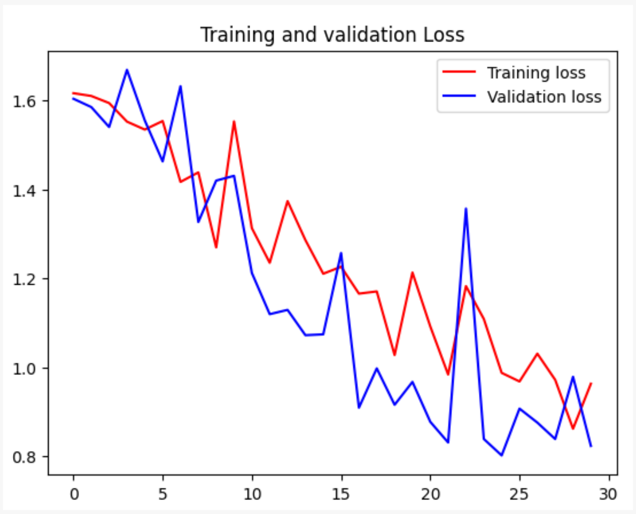


```
Epoch 1/30
8/8 [==============================] - 47s 5s/step - loss: 1.6162 - accuracy: 0.2455 - val_loss: 1.6036 - val_accuracy: 0.2023
Epoch 2/30
8/8 [==============================] - 42s 5s/step - loss: 1.6099 - accuracy: 0.2294 - val_loss: 1.5849 - val_accuracy: 0.2139
Epoch 3/30
8/8 [==============================] - 43s 5s/step - loss: 1.5940 - accuracy: 0.2949 - val_loss: 1.5401 - val_accuracy: 0.3121
Epoch 4/30
8/8 [==============================] - 40s 5s/step - loss: 1.5522 - accuracy: 0.2958 - val_loss: 1.6687 - val_accuracy: 0.2023
Epoch 5/30
8/8 [==============================] - 41s 5s/step - loss: 1.5343 - accuracy: 0.2757 - val_loss: 1.5547 - val_accuracy: 0.3064
Epoch 6/30
8/8 [==============================] - 41s 5s/step - loss: 1.5536 - accuracy: 0.3164 - val_loss: 1.4627 - val_accuracy: 0.3468
Epoch 7/30
8/8 [==============================] - 40s 5s/step - loss: 1.4167 - accuracy: 0.3139 - val_loss: 1.6319 - val_accuracy: 0.2890
Epoch 8/30
8/8 [==============================] - 40s 5s/step - loss: 1.4381 - accuracy: 0.3461 - val_loss: 1.3264 - val_accuracy: 0.3815
Epoch 9/30
8/8 [==============================] - 41s 5s/step - loss: 1.2693 - accuracy: 0.4160 - val_loss: 1.4196 - val_accuracy: 0.3295
Epoch 10/30
8/8 [==============================] - 40s 5s/step - loss: 1.5527 - accuracy: 0.3300 - val_loss: 1.4303 - val_accuracy: 0.3410
Epoch 11/30
8/8 [==============================] - 42s 5s/step - loss: 1.3127 - accuracy: 0.4102 - val_loss: 1.2119 - val_accuracy: 0.4913
Epoch 12/30
8/8 [==============================] - 40s 5s/step - loss: 1.2348 - accuracy: 0.4406 - val_loss: 1.1192 - val_accuracy: 0.5780
Epoch 13/30
8/8 [==============================] - 47s 6s/step - loss: 1.3735 - accuracy: 0.4145 - val_loss: 1.1289 - val_accuracy: 0.6069
Epoch 14/30
8/8 [==============================] - 42s 5s/step - loss: 1.2859 - accuracy: 0.4512 - val_loss: 1.0720 - val_accuracy: 0.5838
Epoch 15/30
8/8 [==============================] - 41s 5s/step - loss: 1.2102 - accuracy: 0.4805 - val_loss: 1.0738 - val_accuracy: 0.5665
Epoch 16/30
8/8 [==============================] - 40s 5s/step - loss: 1.2259 - accuracy: 0.4487 - val_loss: 1.2567 - val_accuracy: 0.3410
Epoch 17/30
8/8 [==============================] - 42s 5s/step - loss: 1.1654 - accuracy: 0.4769 - val_loss: 0.9089 - val_accuracy: 0.6301
Epoch 18/30
8/8 [==============================] - 41s 5s/step - loss: 1.1704 - accuracy: 0.4824 - val_loss: 0.9973 - val_accuracy: 0.6069
Epoch 19/30
8/8 [==============================] - 41s 5s/step - loss: 1.0273 - accuracy: 0.5191 - val_loss: 0.9154 - val_accuracy: 0.6185
Epoch 20/30
8/8 [==============================] - 41s 5s/step - loss: 1.2129 - accuracy: 0.5231 - val_loss: 0.9669 - val_accuracy: 0.6185
Epoch 21/30
8/8 [==============================] - 41s 5s/step - loss: 1.0916 - accuracy: 0.5252 - val_loss: 0.8772 - val_accuracy: 0.6590
Epoch 22/30
8/8 [==============================] - 41s 5s/step - loss: 0.9835 - accuracy: 0.5918 - val_loss: 0.8306 - val_accuracy: 0.6474
Epoch 23/30
8/8 [==============================] - 40s 5s/step - loss: 1.1823 - accuracy: 0.5171 - val_loss: 1.3566 - val_accuracy: 0.3642
Epoch 24/30
8/8 [==============================] - 48s 6s/step - loss: 1.1084 - accuracy: 0.5098 - val_loss: 0.8386 - val_accuracy: 0.6532
Epoch 25/30
8/8 [==============================] - 40s 5s/step - loss: 0.9872 - accuracy: 0.5775 - val_loss: 0.8015 - val_accuracy: 0.6474
Epoch 26/30
8/8 [==============================] - 40s 5s/step - loss: 0.9679 - accuracy: 0.5674 - val_loss: 0.9069 - val_accuracy: 0.6301
Epoch 27/30
8/8 [==============================] - 40s 5s/step - loss: 1.0305 - accuracy: 0.5835 - val_loss: 0.8754 - val_accuracy: 0.6185
Epoch 28/30
8/8 [==============================] - 40s 5s/step - loss: 0.9716 - accuracy: 0.5895 - val_loss: 0.8384 - val_accuracy: 0.6994
Epoch 29/30
8/8 [==============================] - 40s 5s/step - loss: 0.8616 - accuracy: 0.6278 - val_loss: 0.9784 - val_accuracy: 0.5607
Epoch 30/30
8/8 [==============================] - 40s 5s/step - loss: 0.9628 - accuracy: 0.5915 - val_loss: 0.8229 - val_accuracy: 0.6647
```

PLOTTING LOSS AND ACCURACY

```
import matplotlib.pyplot as plt

# Plot the results
acc = history.history['accuracy']
val_acc = history.history['val_accuracy']
loss = history.history['loss']
val_loss = history.history['val_loss']

epochs = range(len(acc))

plt.plot(epochs, acc, 'r', label='Training accuracy')
plt.plot(epochs, val_acc, 'b', label='Validation accuracy')
plt.title('Training and validation accuracy')
plt.legend(loc=0)
plt.figure()

plt.plot(epochs, loss, 'r', label='Training loss')
plt.plot(epochs, val_loss, 'b', label='Validation loss')
plt.title('Training and validation Loss')
plt.legend(loc=0)
plt.figure()

plt.show()
```



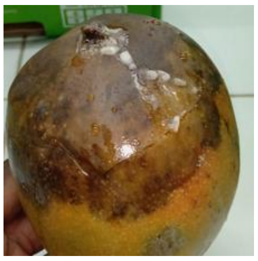


```
import os
import random
import numpy as np
import pandas as pd
import tensorflow as tf
from tensorflow.keras.preprocessing import image
from tensorflow.keras.preprocessing.image import ImageDataGenerator
import matplotlib.pyplot as plt

# Save the model
model.save('/kaggle/working/mango_disease_model.h5')
```

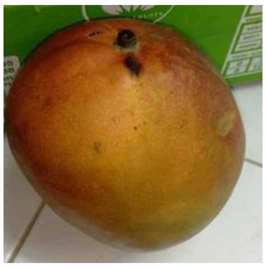
```python
# Function to classify a single image
def classify_image(image_path):
    img = image.load_img(image_path, target_size=(150, 150))
    img_array = image.img_to_array(img)
    img_array = np.expand_dims(img_array, axis=0)
    img_array /= 255.

    # Load the saved model
    model = tf.keras.models.load_model('/kaggle/working/mango_disease_model.h5')

    # Make prediction
    predictions = model.predict(img_array)
    predicted_class = np.argmax(predictions[0])

    # Get class labels from train_generator
    class_labels = list(train_generator.class_indices.keys())

    # Print the prediction
    print(f"Predicted class: {class_labels[predicted_class]}")
    print(f"Confidence: {predictions[0][predicted_class]:.4f}")

# List files in the dataset directories
data_dir = '/kaggle/input/mangofruitdds/MangoFruitDDS/SenMangoFruitDDS_original'
categories = ["Alternaria", "Anthracnose", "Black Mould Rot", "Healthy", "Stem end
Rot"]

# Get a random image path for testing
def get_random_image_path():
    category = random.choice(categories)
    category_dir = os.path.join(data_dir, category)
    if os.path.isdir(category_dir):
        image_filename = random.choice(os.listdir(category_dir))
        return os.path.join(category_dir, image_filename)
    return None

random_image_path = get_random_image_path()
print(f"Random image path: {random_image_path}")

if random_image_path:
    classify_image(random_image_path)
else:
    print("No valid image found for classification.")
```

OUPUT :

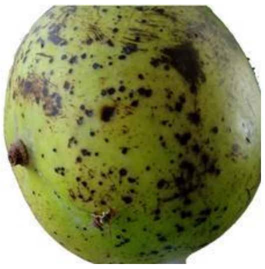
```
Random image path: /kaggle/input/mangofruitdds/MangoFruitDDS/SenMangoFruitDDS_original/Stem end Rot/lasio_074.jpg
1/1 [==============================] - 0s 105ms/step
Predicted class: Stem end Rot
Confidence: 0.7252
```



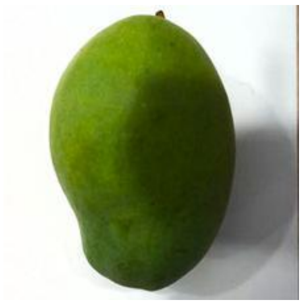
```
Random image path: /kaggle/input/mangofruitdds/MangoFruitDDS/SenMangoFruitDDS_original/Alternaria/alternaria_020.jpg
1/1 [==============================] - 0s 110ms/step
Predicted class: Alternaria
Confidence: 0.4296
```



```
Random image path: /kaggle/input/mangofruitdds/MangoFruitDDS/SenMangoFruitDDS_original/Anthracnose/anthracnose_078.jpg
1/1 [==============================] - 0s 108ms/step
Predicted class: Anthracnose
Confidence: 0.9590
```



```
Random image path: /kaggle/input/mangofruitdds/MangoFruitDDS/SenMangoFruitDDS_original/Healthy/healthy_110.jpg
1/1 [==============================] - 0s 111ms/step
Predicted class: Healthy
Confidence: 0.7661
```

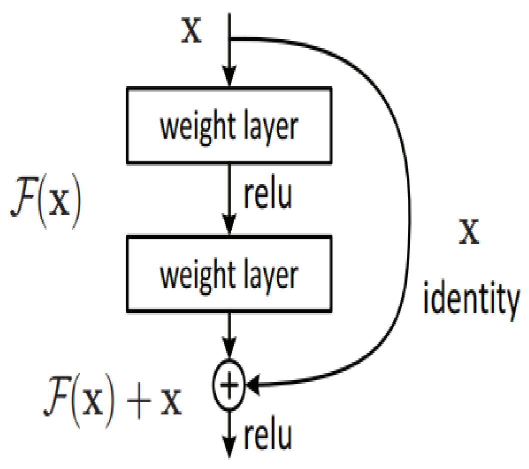


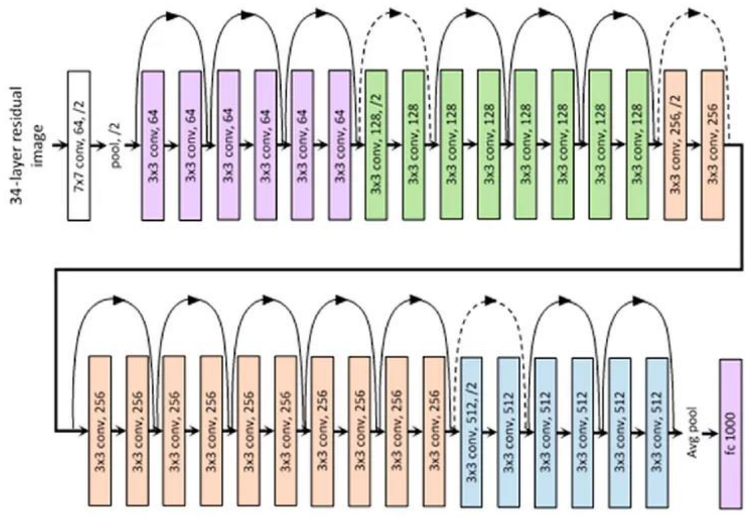
RESIDUAL NETWORK ARCHITECTURE:

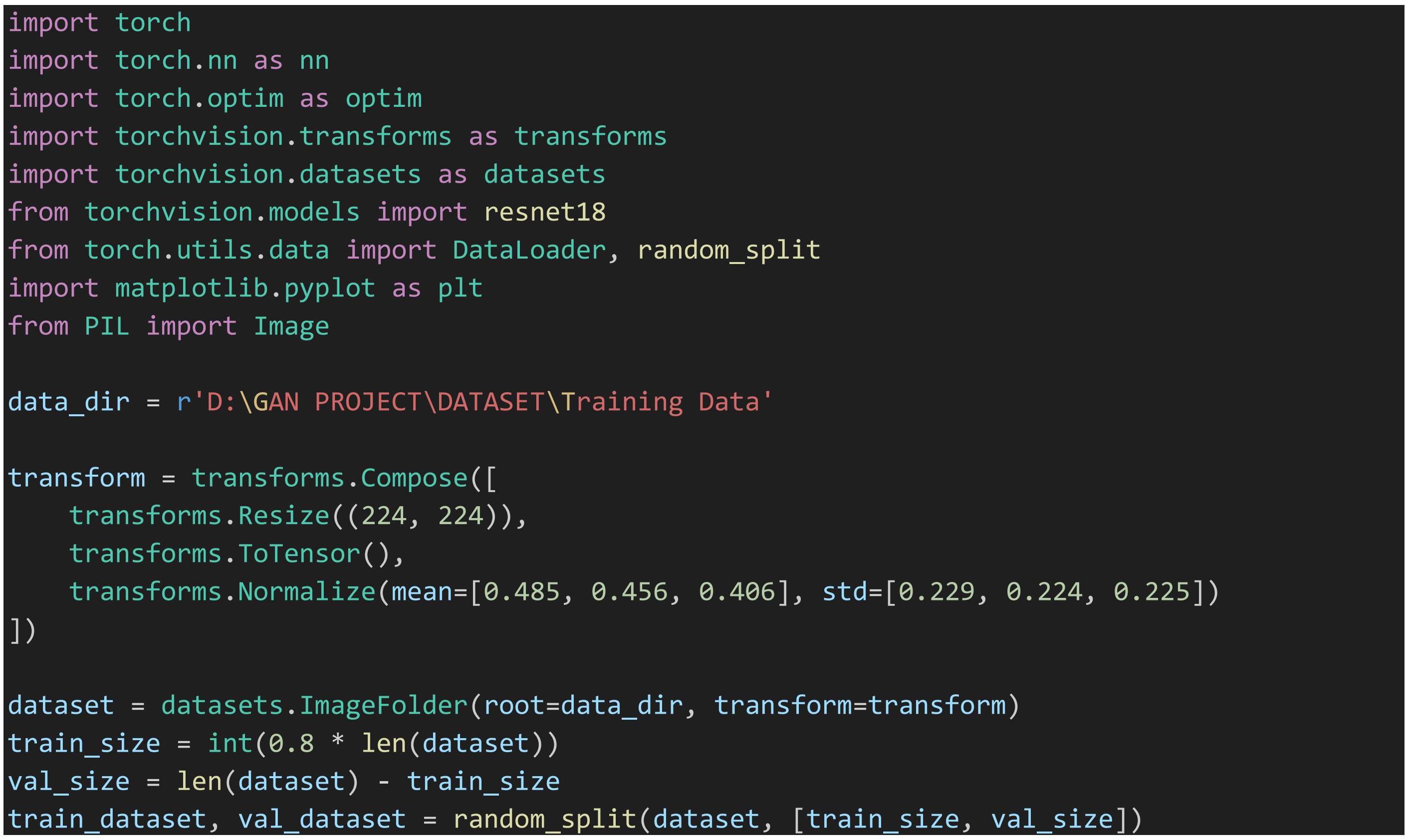
In order to solve the problem of the vanishing/exploding gradient, this architecture introduced the concept called Residual Blocks. In this network, we use a technique called skip connections. The skip connection connects activations of a layer to further layers by skipping some layers in between. This forms a residual block. Resnets are made by stacking these residual blocks together.

The approach behind this network is instead of layers learning the underlying mapping, we allow the network to fit the residual mapping. So, instead of say H(x), initial mapping, let the network fit,

F(x) := H(x) - x which gives H(x) := F(x) + x.







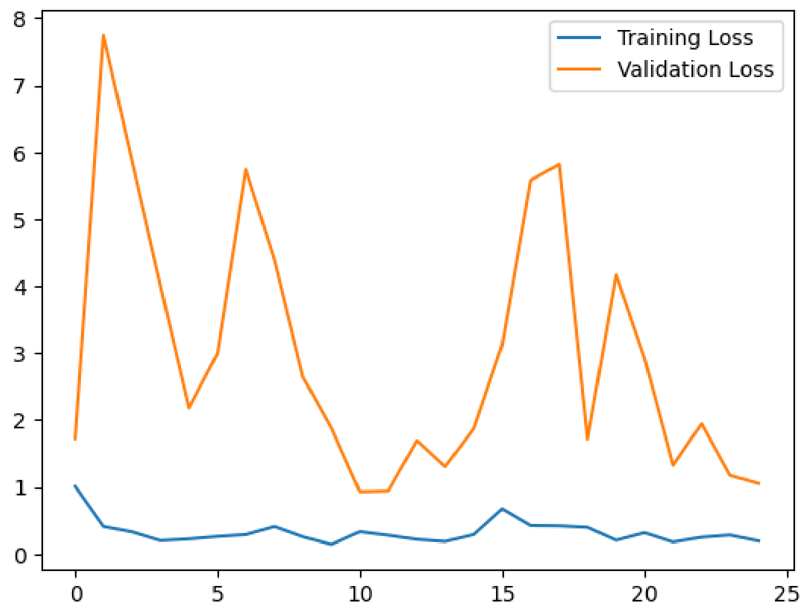
```
import torch
import torch.nn as nn
import torch.optim as optim
import torchvision.transforms as transforms
import torchvision.datasets as datasets
from torchvision.models import resnet18
from torch.utils.data import DataLoader, random_split
import matplotlib.pyplot as plt
from PIL import Image

data_dir = r'D:\GAN PROJECT\DATASET\Training Data'

transform = transforms.Compose([
    transforms.Resize((224, 224)),
    transforms.ToTensor(),
    transforms.Normalize(mean=[0.485, 0.456, 0.406], std=[0.229, 0.224, 0.225])
])

dataset = datasets.ImageFolder(root=data_dir, transform=transform)
train_size = int(0.8 * len(dataset))
val_size = len(dataset) - train_size
train_dataset, val_dataset = random_split(dataset, [train_size, val_size])
```

```python
train_loader = DataLoader(train_dataset, batch_size=32, shuffle=True)
val_loader = DataLoader(val_dataset, batch_size=32, shuffle=False)

model = resnet18(pretrained=True)
num_ftrs = model.fc.in_features
model.fc = nn.Linear(num_ftrs, 5)  # 5 classes

# 3. Model Training
criterion = nn.CrossEntropyLoss()
optimizer = optim.Adam(model.parameters(), lr=0.001)

device = torch.device("cuda:0" if torch.cuda.is_available() else "cpu")
model.to(device)

num_epochs = 25
best_val_acc = 0.0
train_losses, val_losses = [], []

for epoch in range(num_epochs):
    model.train()
    running_loss = 0.0
    for inputs, labels in train_loader:
        inputs, labels = inputs.to(device), labels.to(device)
        optimizer.zero_grad()
        outputs = model(inputs)
        loss = criterion(outputs, labels)
        loss.backward()
        optimizer.step()
        running_loss += loss.item() * inputs.size(0)

    epoch_loss = running_loss / len(train_loader.dataset)
    train_losses.append(epoch_loss)

    model.eval()
    val_loss = 0.0
    corrects = 0
    with torch.no_grad():
        for inputs, labels in val_loader:
            inputs, labels = inputs.to(device), labels.to(device)
            outputs = model(inputs)
            loss = criterion(outputs, labels)
            val_loss += loss.item() * inputs.size(0)
            _, preds = torch.max(outputs, 1)
            corrects += torch.sum(preds == labels.data)

    epoch_val_loss = val_loss / len(val_loader.dataset)
    val_losses.append(epoch_val_loss)
    val_acc = corrects.double() / len(val_loader.dataset)

    if val_acc > best_val_acc:
        best_val_acc = val_acc
        torch.save(model.state_dict(), 'best_model.pth')
    print(f'Epoch {epoch}/{num_epochs-1}, Train Loss: {epoch_loss:.4f},
          Val Loss: {epoch_val_loss:.4f}, Val Acc: {val_acc:.4f}')

plt.figure()
plt.plot(range(num_epochs), train_losses, label='Training Loss')
plt.plot(range(num_epochs), val_losses, label='Validation Loss')
plt.legend()
plt.show()

model.load_state_dict(torch.load('best_model.pth'))
model.eval()

corrects = 0
with torch.no_grad():
    for inputs, labels in val_loader:
        inputs, labels = inputs.to(device), labels.to(device)
        outputs = model(inputs)
        _, preds = torch.max(outputs, 1)
        corrects += torch.sum(preds == labels.data)

val_acc = corrects.double() / len(val_loader.dataset)
print(f'Validation Accuracy: {val_acc:.4f}')

def predict_image(image_path):
    image = Image.open(image_path)
    image = transform(image).unsqueeze(0).to(device)
    model.eval()
    with torch.no_grad():
        outputs = model(image)
        _, preds = torch.max(outputs, 1)
    return dataset.classes[preds[0]]

# Test the prediction function
test_image_path = r'D:\GAN PROJECT\DATASET\Testing Data\Healthy\healthy_109.jpg'
print(f'Predicted Class: {predict_image(test_image_path)}')
```

Calculating Train Loss , Validation Loss, Validation Accuracy

```
Epoch 0/24, Train Loss: 1.0103, Val Loss: 1.7221, Val Acc: 0.4146

Epoch 1/24, Train Loss: 0.4102, Val Loss: 7.7499, Val Acc: 0.2683

Epoch 2/24, Train Loss: 0.3304, Val Loss: 5.8711, Val Acc: 0.3659

Epoch 3/24, Train Loss: 0.2021, Val Loss: 4.0103, Val Acc: 0.3902

Epoch 4/24, Train Loss: 0.2254, Val Loss: 2.1796, Val Acc: 0.6098

Epoch 5/24, Train Loss: 0.2615, Val Loss: 2.9954, Val Acc: 0.6341

Epoch 6/24, Train Loss: 0.2894, Val Loss: 5.7425, Val Acc: 0.5122

Epoch 7/24, Train Loss: 0.4095, Val Loss: 4.3949, Val Acc: 0.5366

Epoch 8/24, Train Loss: 0.2581, Val Loss: 2.6480, Val Acc: 0.6098

Epoch 9/24, Train Loss: 0.1425, Val Loss: 1.8820, Val Acc: 0.6829

Epoch 10/24, Train Loss: 0.3324, Val Loss: 0.9290, Val Acc: 0.6829

Epoch 11/24, Train Loss: 0.2800, Val Loss: 0.9397, Val Acc: 0.7561

Epoch 12/24, Train Loss: 0.2191, Val Loss: 1.6942, Val Acc: 0.6098

Epoch 13/24, Train Loss: 0.1883, Val Loss: 1.3047, Val Acc: 0.6585

Epoch 14/24, Train Loss: 0.2898, Val Loss: 1.8727, Val Acc: 0.4878

Epoch 15/24, Train Loss: 0.6723, Val Loss: 3.1246, Val Acc: 0.6098

Epoch 16/24, Train Loss: 0.4247, Val Loss: 5.5820, Val Acc: 0.5122

Epoch 17/24, Train Loss: 0.4195, Val Loss: 5.8186, Val Acc: 0.3171

Epoch 18/24, Train Loss: 0.3979, Val Loss: 1.7144, Val Acc: 0.5854

Epoch 19/24, Train Loss: 0.2063, Val Loss: 4.1694, Val Acc: 0.4146

Epoch 20/24, Train Loss: 0.3171, Val Loss: 2.9240, Val Acc: 0.4878

Epoch 21/24, Train Loss: 0.1801, Val Loss: 1.3247, Val Acc: 0.6829

Epoch 22/24, Train Loss: 0.2510, Val Loss: 1.9458, Val Acc: 0.5366

Epoch 23/24, Train Loss: 0.2827, Val Loss: 1.1738, Val Acc: 0.7073

Epoch 24/24, Train Loss: 0.1960, Val Loss: 1.0539, Val Acc: 0.6341
```

PLOTTING VALIDATION AND TRAINING LOSS



OUTPUT EXAMPLE 1

```
# Test the prediction function
test_image_path = r'D:\GAN PROJECT\DATASET\Testing Data\Healthy\healthy_109.jpg'
print(f'Predicted Class: {predict_image(test_image_path)}')
```

OUTPUT :

```
C:\Users\balas\AppData\Local\Temp\ipykernel_3412\2445199636.py:90:
  model.load_state_dict(torch.load('best_model.pth'))
Validation Accuracy: 0.7561
Predicted Class: Healthy
```

OUTPUT EXAMPLE 2

```
# Test the prediction function
test_image_path = r'D:\GAN PROJECT\DATASET\Testing Data\Alternaria\alternaria_117.jpg'
print(f'Predicted Class: {predict_image(test_image_path)}')
 2.4s
```

OUTPUT :

```
C:\Users\balas\AppData\Local\Temp\ipykernel_3412\2076789063.py:1:
  model.load_state_dict(torch.load('best_model.pth'))
Validation Accuracy: 0.7561
Predicted Class: Alternaria
```

OUTPUT EXAMPLE 3

```
# Test the prediction function
test_image_path = r'd:\GAN PROJECT\DATASET\Testing Data\Black Mould
Rot\aspergillus_138.jpg'  # Ensure the test image path is correct
print(f'Predicted Class: {predict_image(test_image_path)}')
```

OUTPUT :

```
C:\Users\balas\AppData\Local\Temp\ipykernel_3412\4079759776.py:1:
  model.load_state_dict(torch.load('best_model.pth'))
Validation Accuracy: 0.7561
Predicted Class: Black Mould Rot
```