Plant Pathology
(Image Classification)

Plant_Pathology Dataset

- Given a photo of an apple leaf, can you accurately assess its health? This competition will challenge you to distinguish between leaves which are healthy, those which are infected with apple rust, those that have apple scab, and those with more than one disease.
- A folder containing the train and test images, in jpg format.

1-PreProcessing

Read Data

In [ ]:

```
train_df = pd.read_csv("/kaggle/input/plant-pathology-2020-fgvc7/train.csv")
train_df['img_name'] = train_df['image_id'] + ".jpg"
train_df.head()
```

Out[4]:

	image_id	healthy	multiple_diseases	rust	scab	img_name
0	Train_0	0	0	0	1	Train_0.jpg
1	Train_1	0	1	0	0	Train_1.jpg
2	Train_2	1	0	0	0	Train_2.jpg
3	Train_3	0	0	1	0	Train_3.jpg
4	Train_4	1	0	0	0	Train_4.jpg

Determine Directions

```
In [ ]:
from shutil import copyfile

# delete temp dir
if os.path.exists('/kaggle/temp/'):
    shutil.rmtree('/kaggle/temp/')

os.mkdir('/kaggle/temp/')

# train directory
os.mkdir('/kaggle/temp/train')
os.mkdir('/kaggle/temp/train/healthy')
os.mkdir('/kaggle/temp/train/multiple_diseases')
os.mkdir('/kaggle/temp/train/rust')
os.mkdir('/kaggle/temp/train/scab')

# validation directory
os.mkdir('/kaggle/temp/valid')
os.mkdir('/kaggle/temp/valid/healthy')
os.mkdir('/kaggle/temp/valid/multiple_diseases')
os.mkdir('/kaggle/temp/valid/rust')
os.mkdir('/kaggle/temp/valid/scab')
```

```
In [ ]:
SOURCE = '/kaggle/input/plant-pathology-2020-fgvc7/images/'

TRAIN_DIR = '/kaggle/temp/train/'

# copy images to train directory
for index, data in train_set.iterrows():
    label = df.columns[np.argmax(data)]
    filepath = os.path.join(SOURCE, index + ".jpg")
    destination = os.path.join(TRAIN_DIR, label, index + ".jpg")
    copyfile(filepath, destination)

for subdir in os.listdir(TRAIN_DIR):
    print(subdir, len(os.listdir(os.path.join(TRAIN_DIR, subdir))))
```

```
healthy 416
scab 465
multiple_diseases 73
rust 502
```

```
In [ ]:
VALID_DIR = '/kaggle/temp/valid/'

# copy images to valid directory
for index, data in valid_set.iterrows():
    label = df.columns[np.argmax(data)]
    filepath = os.path.join(SOURCE, index + ".jpg")
    destination = os.path.join(VALID_DIR, label, index + ".jpg")
    copyfile(filepath, destination)

for subdir in os.listdir(VALID_DIR):
    print(subdir, len(os.listdir(os.path.join(VALID_DIR, subdir))))
```

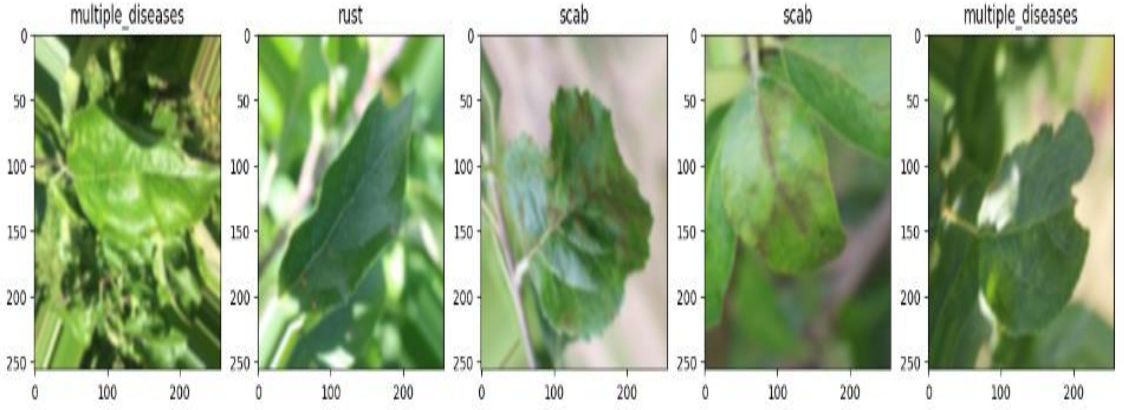
```
healthy 100
scab 127
multiple_diseases 18
rust 120
```

```
In [ ]:
healthy_dir = os.path.join(TRAIN_DIR, 'healthy')
mdiseases_dir = os.path.join(TRAIN_DIR, 'multiple_diseases')
scab_dir = os.path.join(TRAIN_DIR, 'scab')
rust_dir = os.path.join(TRAIN_DIR, 'rust')

healthy_files = os.listdir(healthy_dir)
mdiseases_files = os.listdir(mdiseases_dir)
scab_files = os.listdir(scab_dir)
rust_files = os.listdir(rust_dir)
```

Data Visualization

In [ ]:
```
%matplotlib inline

import matplotlib.pyplot as plt
import matplotlib.image as mpimg

pic_index = 2

next_healthy = [os.path.join(healthy_dir, fname) for fname in healthy_files[pic_index-2:pic_index]]
next_mdiseases = [os.path.join(mdiseases_dir, fname) for fname in mdiseases_files[pic_index-2:pic_index]]
next_scab = [os.path.join(scab_dir, fname) for fname in scab_files[pic_index-2:pic_index]]
next_rust = [os.path.join(rust_dir, fname) for fname in rust_files[pic_index-2:pic_index]]


nrows = 4
ncols = 4

fig = plt.gcf()
fig.set_size_inches(ncols*4, nrows*4)

for i, img_path in enumerate(next_healthy+next_mdiseases+next_scab+next_rust):
    sp = plt.subplot(nrows, ncols, i + 1)
    sp.axis('Off') # Don't show axes (or gridlines)
    img = mpimg.imread(img_path)
    plt.title(img_path.split('/')[-2])
    plt.imshow(img)

plt.show()
```

In [ ]:
```
def show_imgs(df, num):
    fig, ax = plt.subplots(1,num, figsize=(18,9))
    for x, y in df:
        for img in range(num):
            ax[img].imshow(x[img])
            if y[img][0]:
                title="healthy"
            elif y[img][1]:
                title='multiple_diseases'
            elif y[img][2]:
                title='rust'
            elif y[img][3] :
                title='scab'
            ax[img].set_title(title)
        break
```



Data Balance
(Over Sampling)

```
target_multi_cols = ['healthy', 'multiple_diseases', 'rust', 'scab']

print("Multi Classification Targets")
print(train_df[target_multi_cols].sum())
```

```
Multi Classification Targets
healthy              516
multiple_diseases     91
rust                 622
scab                 592
dtype: int64
```

Maka data balance (over sampling)

```
def balance_set(df, x_cols, y_cols):
    ros = RandomOverSampler(random_state=42)

    x_multi, y_multi = ros.fit_resample(df[x_cols], df[y_cols].values)
    data = pd.concat([x_multi, pd.DataFrame(y_multi, columns= y_cols)], axis=1)
    return data

train_multi = balance_set(train_df,
                          x_cols = ["image_id", "img_name"],
                          y_cols = target_multi_cols)


labels = train_multi[target_multi_cols]
label_names = labels[labels==1].stack().reset_index()['level_1']
label_names.index = train_multi.index
train_multi['label_names'] = label_names

print("Multi Classification Labels")
print(train_multi[target_multi_cols].sum())
```

```
Multi Classification Labels
healthy              622
multiple_diseases    622
rust                 622
scab                 622
dtype: int64
```

Data Split
(Train&Validation)

```
from sklearn.model_selection import train_test_split

train_set, valid_set = train_test_split(df, test_size=0.2, random_state=42)

print(train_set.shape)
print(valid_set.shape)
```

```
(1456, 4)
(365, 4)
```

```
tf.random.set_seed(99)
img_data_generator = ImageDataGenerator(rescale=1/255,
                                        validation_split=0.2,
                                        rotation_range = 180,
                                        horizontal_flip = True,
                                        vertical_flip = True,
                                        preprocessing_function=blur_preprocessing
                                       )
```

Image Generator

Before Balance

```
import tensorflow as tf
from tensorflow import keras
import tensorflow_datasets as tfds
import os
import cv2
from sklearn.model_selection import train_test_split
import numpy as np
import matplotlib.pyplot as plt
import tensorflow.keras.layers as tfl
import pandas as pd
from tensorflow.keras.models import Model
from tensorflow.keras.preprocessing import image_dataset_from_directory
from tensorflow.keras.layers.experimental.preprocessing import RandomFlip, RandomRotation
from PIL import Image
import csv
from tensorflow.keras.preprocessing import image
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)

#test_datagen = ImageDataGenerator( rescale = 1.0/255. )

train_generator = training_datagen.flow_from_directory(TRAIN_DIR, target_size=(150,150), class_mode='categorical', batch_size=32
validation_generator = validation_datagen.flow_from_directory(VALID_DIR, target_size=(150,150), class_mode='categorical', batch_
```

```
Found 1456 images belonging to 4 classes.
Found 365 images belonging to 4 classes.
```

After Balance

```
def blur_preprocessing(img):
    return cv2.blur(img, (5, 5))

tf.random.set_seed(99)
img_data_generator = ImageDataGenerator(rescale=1/255,
                                        validation_split=0.2,
                                        rotation_range = 180,
                                        horizontal_flip = True,
                                        vertical_flip = True,
                                        preprocessing_function=blur_preprocessing
                                       )


train_data_multi = img_data_generator.flow_from_dataframe(dataframe=train_multi,
                                                          directory="/kaggle/input/plant-pathology-2020-fgvc7/images/",
                                                          x_col="img_name",
                                                          y_col= "label_names",
                                                          target_size=(256, 256),
                                                          class_mode='categorical',
                                                          batch_size=32,
                                                          subset='training',
                                                          shuffle=True,
                                                          seed=42)

val_data_multi = img_data_generator.flow_from_dataframe(dataframe=train_multi,
                                                        directory="/kaggle/input/plant-pathology-2020-fgvc7/images/",
                                                        x_col="img_name",
                                                        y_col="label_names",
                                                        target_size=(256, 256),
                                                        class_mode='categorical',
                                                        batch_size=32,
                                                        subset='validation',
                                                        shuffle=True,
                                                        seed=42)
```

```
Found 1991 validated image filenames belonging to 4 classes.
Found 497 validated image filenames belonging to 4 classes.
```

Blur preprocessing

```
def blur_preprocessing(img):
    return cv2.blur(img, (5, 5))
```

Learning rate scheduler

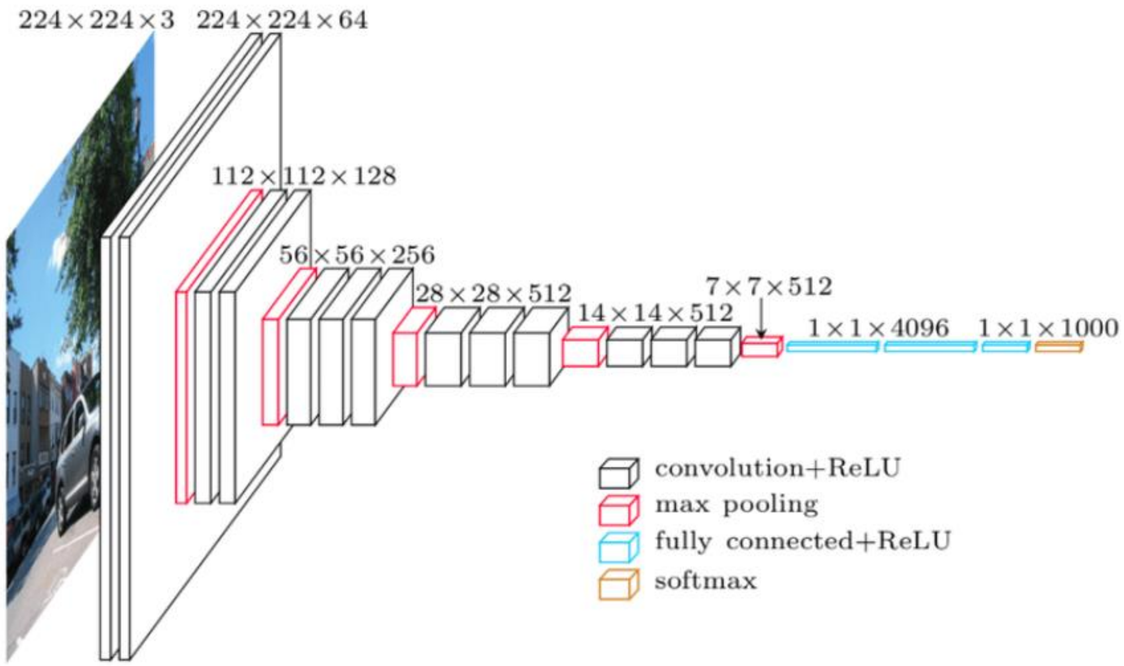
```
learning_rate_scheduler = tf.keras.optimizers.schedules.ExponentialDecay(initial_learning_rate=0.0003,
                                                                          decay_steps=2,
                                                                          decay_rate=0.97,
```

2-Image Classification Models

1- VGG16 (Pretrained Model)

- What Is VGG16?
  - ➢ VGG16 refers to the VGG model, also called VGGNet. It is a convolution neural network (CNN) model supporting 16 layers.
  - ➢ The VGG16 model can achieve a test accuracy of 92.7% in ImageNet, a dataset containing more than 14 million training images across 1000 object classes. It is one of the top models from the ILSVRC-2014 competition.

VGG16 Architecture



VGG16 modeling

(Transfer learning – compile - fit – load model - evaluation)

```
from tensorflow.keras.applications.vgg16 import VGG16
base_model = VGG16(input_shape = (150, 150, 3), # Shape of our images
include_top = False, # Leave out the last fully connected layer
weights = 'imagenet')
```

```
import tensorflow as tf
import keras
from keras import layers
for layer in base_model.layers:
    layer.trainable = False
    tf.keras.layers.BatchNormalization()
```

```
# Flatten the output layer to 1 dimension
x = layers.Flatten()(base_model.output)
# Add a fully connected layer with 512 hidden units and ReLU activation
x = layers.Dense(512, activation='relu')(x)
# Add a dropout rate of 0.5
x = layers.Dropout(0.5)(x)
# Add a final sigmoid layer with 1 node for classification output
x = layers.Dense(4, activation='softmax')(x)
model = tf.keras.models.Model(base_model.input, x)
model.compile(optimizer='Adam', loss='categorical_crossentropy',metrics = ['acc'])
early_stopping_cb = tf.keras.callbacks.EarlyStopping(patience=5)
checkpoint_cb = tf.keras.callbacks.ModelCheckpoint("vgg16.h5", save_best_only=True)
```

```
vgghist = model.fit(train_generator, validation_data = validation_generator, steps_per_epoch = 10, epochs = 15, validation_s
```

Visualize train and validation accuracy

```
import matplotlib.pyplot as plt
acc = vgghist.history['acc']
val_acc = vgghist.history['val_acc']
loss = vgghist.history['loss']
val_loss = vgghist.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.show()
```

Evatuation

```
model = tf.keras.models.load_model("vgg16.h5") # rollback to best model
model.evaluate(validation_generator)
```

VGG16 modeling

(read test data – make predictions)

In [ ]:
```python
test_set = pd.read_csv("/kaggle/input/plant-pathology-2020-fgvc7/test.csv", index_col=0)

X_test = []
for index, data in test_set.iterrows():
    filepath = os.path.join(SOURCE, index + ".jpg")
    img = image.load_img(filepath, target_size=(150, 150))
    x = image.img_to_array(img)
    x = np.expand_dims(x, axis=0)
    X_test.append(x)

X_test = np.vstack(X_test) / 255 # rescale images
```

predict the test data

In [ ]:
```python
y_pred = model.predict(X_test, batch_size=10)
df_out = pd.concat([test_set.reset_index(), pd.DataFrame(y_pred, columns = train_generator.class_indices.keys())], axis=1).se
df_out.to_csv('submission.csv')
df_out.head()
```

```
183/183 [==============================] - 7s 30ms/step
```

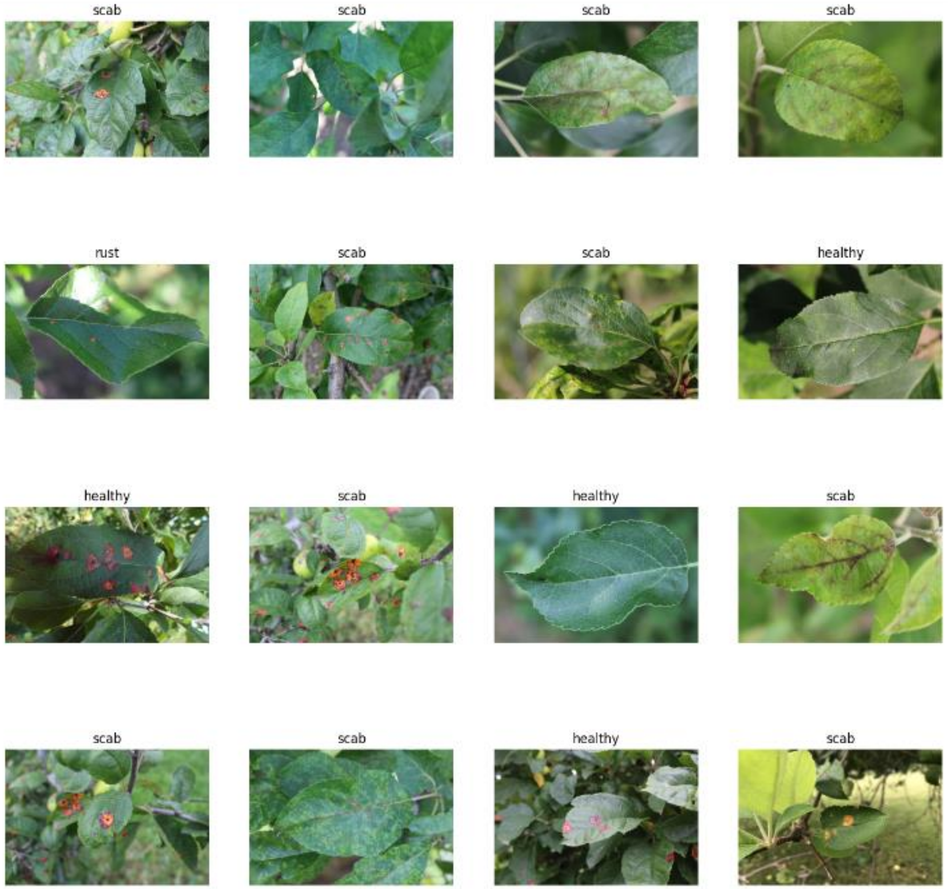
Out[19]:

image_id	healthy	multiple_diseases	rust	scab
Test_0	0.106944	0.044960	0.239254	0.608842
Test_1	0.199255	0.047042	0.460560	0.293144
Test_2	0.014253	0.024624	0.089598	0.871525
Test_3	0.552810	0.033190	0.152912	0.261087
Test_4	0.187862	0.061119	0.353388	0.397631

VGG16 modeling

(Predictions)

```
ncols = 4

fig = plt.gcf()
fig.set_size_inches(ncols*4, nrows*4)

for i, (idx, row) in enumerate(df_out.sample(nrows*ncols).iterrows()):
    filepath = filepath = os.path.join(SOURCE, idx + ".jpg")
    sp = plt.subplot(nrows, ncols, i + 1)
    sp.axis('Off') # Don't show axes (or gridlines)
    img = mpimg.imread(filepath)--
    plt.title(df_out.columns[np.argmax(row)])
    plt.imshow(img)
```



2- Second Model (Build the model)

Second model (Created model)

```
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(4, activation='softmax')
])
```

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

 max_pooling2d_4 (MaxPooling  (None, 74, 74, 64)       0
 2D)

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

 max_pooling2d_5 (MaxPooling  (None, 36, 36, 64)       0
 2D)

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

 max_pooling2d_6 (MaxPooling  (None, 17, 17, 128)      0
 2D)

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

 max_pooling2d_7 (MaxPooling  (None, 7, 7, 128)        0
 2D)

 flatten_1 (Flatten)         (None, 6272)              0

 dropout_1 (Dropout)         (None, 6272)              0

 dense_2 (Dense)             (None, 512)               3211776

 dense_3 (Dense)             (None, 4)                 2052

=================================================================
Total params: 3,473,988
Trainable params: 3,473,988
Non-trainable params: 0
_________________________________________________________________
```

Second Model

(compile - fit)

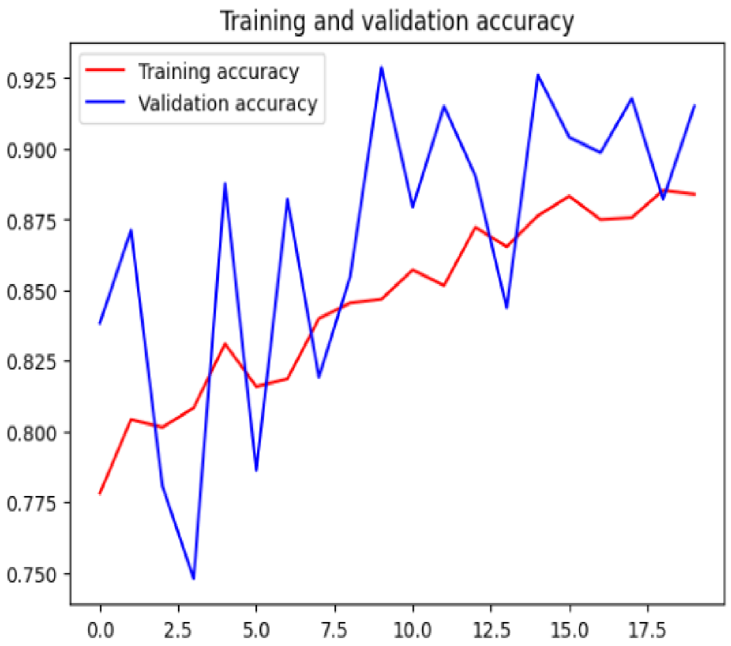
```
model.compile(loss = 'categorical_crossentropy', optimizer='rmsprop', metrics=['accuracy'])

early_stopping_cb = tf.keras.callbacks.EarlyStopping(patience=5)
checkpoint_cb = tf.keras.callbacks.ModelCheckpoint("cm.h5", save_best_only=True)

history = model.fit(train_generator, epochs=50, steps_per_epoch=46,
                    validation_data = validation_generator, validation_steps=12, callbacks=[early_stopping_cb, checkpoint_cb]
```

```
Epoch 1/50
46/46 [==============================] - 29s 594ms/step - loss: 0.6115 - accuracy: 0.7782 - val_loss: 0.4194 - val_accuracy: 0.
8384
Epoch 2/50
46/46 [==============================] - 27s 589ms/step - loss: 0.5390 - accuracy: 0.8043 - val_loss: 0.3652 - val_accuracy: 0.
8712
Epoch 3/50
46/46 [==============================] - 28s 606ms/step - loss: 0.5331 - accuracy: 0.8015 - val_loss: 0.5373 - val_accuracy: 0.
7808
Epoch 4/50
46/46 [==============================] - 28s 606ms/step - loss: 0.5130 - accuracy: 0.8084 - val_loss: 0.5944 - val_accuracy: 0.
7479
Epoch 5/50
46/46 [==============================] - 27s 597ms/step - loss: 0.4785 - accuracy: 0.8310 - val_loss: 0.3099 - val_accuracy: 0.
8877
Epoch 6/50
46/46 [==============================] - 28s 609ms/step - loss: 0.5099 - accuracy: 0.8159 - val_loss: 0.5052 - val_accuracy: 0.
7863
Epoch 7/50
46/46 [==============================] - 28s 611ms/step - loss: 0.5072 - accuracy: 0.8187 - val_loss: 0.3551 - val_accuracy: 0.
8822
Epoch 8/50
46/46 [==============================] - 28s 609ms/step - loss: 0.4575 - accuracy: 0.8400 - val_loss: 0.4851 - val_accuracy: 0.
8192
Epoch 9/50
46/46 [==============================] - 27s 588ms/step - loss: 0.4559 - accuracy: 0.8455 - val_loss: 0.4275 - val_accuracy: 0.
8548
Epoch 10/50
46/46 [==============================] - 27s 583ms/step - loss: 0.4740 - accuracy: 0.8468 - val_loss: 0.2493 - val_accuracy: 0.
9288
Epoch 11/50
46/46 [==============================] - 27s 584ms/step - loss: 0.4095 - accuracy: 0.8571 - val_loss: 0.3297 - val_accuracy: 0.
8795
Epoch 12/50
46/46 [==============================] - 27s 592ms/step - loss: 0.4077 - accuracy: 0.8516 - val_loss: 0.2552 - val_accuracy: 0.
9151
Epoch 13/50
46/46 [==============================] - 28s 618ms/step - loss: 0.3895 - accuracy: 0.8723 - val_loss: 0.2987 - val_accuracy: 0.
8904
Epoch 14/50
46/46 [==============================] - 27s 591ms/step - loss: 0.4016 - accuracy: 0.8654 - val_loss: 0.4763 - val_accuracy: 0.
8438
Epoch 15/50
46/46 [==============================] - 28s 603ms/step - loss: 0.3788 - accuracy: 0.8764 - val_loss: 0.2368 - val_accuracy: 0.
9260
Epoch 16/50
46/46 [==============================] - 28s 602ms/step - loss: 0.3448 - accuracy: 0.8832 - val_loss: 0.3211 - val_accuracy: 0.
9041
Epoch 17/50
46/46 [==============================] - 26s 575ms/step - loss: 0.3652 - accuracy: 0.8750 - val_loss: 0.2832 - val_accuracy: 0.
8986
Epoch 18/50
46/46 [==============================] - 27s 587ms/step - loss: 0.3788 - accuracy: 0.8757 - val_loss: 0.2590 - val_accuracy: 0.
9178
Epoch 19/50
46/46 [==============================] - 27s 582ms/step - loss: 0.3467 - accuracy: 0.8853 - val_loss: 0.3358 - val_accuracy: 0.
8822
Epoch 20/50
46/46 [==============================] - 27s 595ms/step - loss: 0.3446 - accuracy: 0.8839 - val_loss: 0.2467 - val_accuracy: 0.
9151
```

Second Model

(train and validation accuracy visualization – load model - evaluation)

```
In [ ]: import matplotlib.pyplot as plt
        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)
```




```
In [ ]: model = tf.keras.models.load_model("cm.h5") # rollback to best model
        model.evaluate(validation_generator)

12/12 [==============================] - 4s 337ms/step - loss: 0.2368 - accuracy: 0.9260

Out[25]: [0.2368302196264267, 0.9260274171829224]
```

Second Model

(read test data – make predictions)

In [ ]:

```python
test_set = pd.read_csv("/kaggle/input/plant-pathology-2020-fgvc7/test.csv", index_col=0)

X_test = []
for index, data in test_set.iterrows():
    filepath = os.path.join(SOURCE, index + ".jpg")
    img = image.load_img(filepath, target_size=(150, 150))
    x = image.img_to_array(img)
    x = np.expand_dims(x, axis=0)
    X_test.append(x)

X_test = np.vstack(X_test) / 255 # rescale images
```

In [ ]:

```python
y_pred = model.predict(X_test, batch_size=10)
df_out = pd.concat([test_set.reset_index(), pd.DataFrame(y_pred, columns = train_generator.class_indices.keys())], axis=1).se
df_out.to_csv('submission.csv')
df_out.head()
```

```
183/183 [==============================] - 1s 4ms/step
```

Out[27]:

image_id	healthy	multiple_diseases	rust	scab
Test_0	6.722297e-12	0.000572	0.999428	7.045307e-13
Test_1	1.999887e-08	0.015762	0.984238	1.652383e-08
Test_2	4.754157e-02	0.017981	0.000729	9.337487e-01
Test_3	8.150271e-01	0.023522	0.002990	1.584612e-01
Test_4	1.529118e-18	0.001206	0.998794	3.132368e-18

Second Model

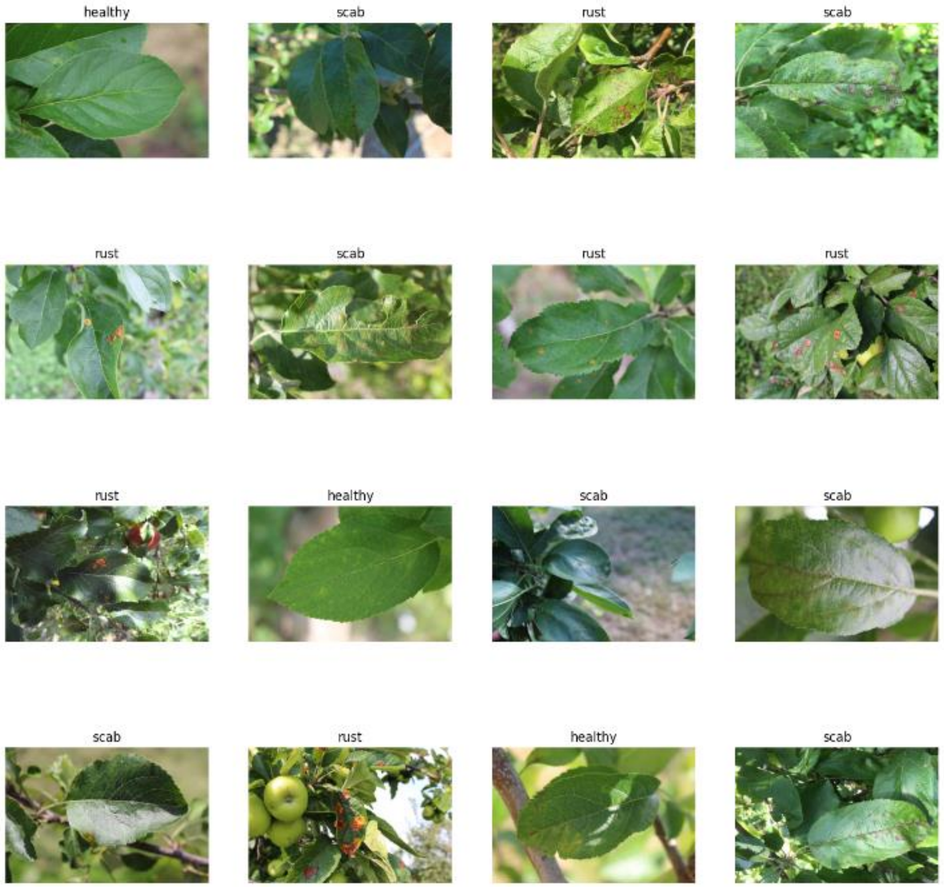
(Predictions)

```python
In [ ]: nrows = 4
        ncols = 4

        fig = plt.gcf()
        fig.set_size_inches(ncols*4, nrows*4)

        for i, (idx, row) in enumerate(df_out.sample(nrows*ncols).iterrows()):
            filepath = filepath = os.path.join(SOURCE, idx + ".jpg")
            sp = plt.subplot(nrows, ncols, i + 1)
            sp.axis('Off') # Don't show axes (or gridlines)
            img = mpimg.imread(filepath)
            plt.title(df_out.columns[np.argmax(row)])
            plt.imshow(img)

        plt.show()
```



A DenseNet is a type of convolutional neural network that utilises dense connections between layers, through Dense Blocks, where we connect all layers (with matching feature-map sizes) directly with each other.

3- Dense Net
Pretrained Model

3- Dense Net

Pretrained Model

(Import dense model -Transfer learning – compile - fit)

```
from tensorflow.keras.applications import DenseNet201
def dense_net_model(trainable_weights=False, weights_path=None):

    tf.keras.backend.clear_session()

    dense_net = DenseNet201(input_shape=(256, 256, 3), weights="imagenet", include_top=False)

    for layer in dense_net.layers:
        layer.trainable=trainable_weights

    model = tf.keras.models.Sequential([dense_net,
                                        tf.keras.layers.GlobalAveragePooling2D(),
                                        tf.keras.layers.Dense(128, activation='relu'),
                                        tf.keras.layers.Dropout(0.3),
                                        tf.keras.layers.Dense(4, activation='softmax')])

    if weights_path:
        model.load_weights(weights_path)

    optimizer = tf.keras.optimizers.Adam(learning_rate=learning_rate_scheduler)
    model.compile(loss="categorical_crossentropy", optimizer=optimizer, metrics=['accuracy'])

    return model

early_stopping_cb = tf.keras.callbacks.EarlyStopping(patience=3)
checkpoint_cb = tf.keras.callbacks.ModelCheckpoint("dense.h5", save_best_only=True)

dense_net_transfer = dense_net_model(trainable_weights=True)

dense_net_transfer_history = dense_net_transfer.fit(train_data_multi, validation_data=val_data_multi, epochs=25, steps_per_ep
```

Dense Net

Pretrained Model

(Import dense model -Transfer learning – compile - fit)

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dense_net_transfer_history = dense_net_transfer.fit(train_data_multi, validation_data=val_data_multi, epochs=25, steps_per_ep
```

```
Epoch 1/25
32/32 [==============================] - 218s 2s/step - loss: 0.6594 - accuracy: 0.7178 - val_loss: 1.6250 - val_accuracy: 0.40
24
Epoch 2/25
32/32 [==============================] - 57s 2s/step - loss: 0.2936 - accuracy: 0.8959 - val_loss: 0.4921 - val_accuracy: 0.833
8
Epoch 3/25
32/32 [==============================] - 51s 2s/step - loss: 0.2444 - accuracy: 0.9039 - val_loss: 0.3598 - val_accuracy: 0.869
2
Epoch 4/25
32/32 [==============================] - 54s 2s/step - loss: 0.1365 - accuracy: 0.9521 - val_loss: 0.3204 - val_accuracy: 0.889
3
Epoch 5/25
32/32 [==============================] - 52s 2s/step - loss: 0.0981 - accuracy: 0.9697 - val_loss: 0.2028 - val_accuracy: 0.939
6
Epoch 6/25
32/32 [==============================] - 53s 2s/step - loss: 0.0956 - accuracy: 0.9717 - val_loss: 0.1788 - val_accuracy: 0.949
7
Epoch 7/25
32/32 [==============================] - 53s 2s/step - loss: 0.0914 - accuracy: 0.9710 - val_loss: 0.1631 - val_accuracy: 0.955
7
Epoch 8/25
32/32 [==============================] - 55s 2s/step - loss: 0.0840 - accuracy: 0.9688 - val_loss: 0.1681 - val_accuracy: 0.953
7
Epoch 9/25
32/32 [==============================] - 50s 2s/step - loss: 0.0640 - accuracy: 0.9820 - val_loss: 0.1597 - val_accuracy: 0.943
7
Epoch 10/25
32/32 [==============================] - 51s 2s/step - loss: 0.0737 - accuracy: 0.9780 - val_loss: 0.1388 - val_accuracy: 0.957
7
Epoch 11/25
32/32 [==============================] - 50s 2s/step - loss: 0.0733 - accuracy: 0.9820 - val_loss: 0.1218 - val_accuracy: 0.959
8
Epoch 12/25
32/32 [==============================] - 51s 2s/step - loss: 0.0738 - accuracy: 0.9736 - val_loss: 0.1112 - val_accuracy: 0.965
8
Epoch 13/25
32/32 [==============================] - 49s 2s/step - loss: 0.0666 - accuracy: 0.9824 - val_loss: 0.1234 - val_accuracy: 0.967
8
Epoch 14/25
32/32 [==============================] - 50s 2s/step - loss: 0.0828 - accuracy: 0.9780 - val_loss: 0.1070 - val_accuracy: 0.971
8
Epoch 15/25
32/32 [==============================] - 52s 2s/step - loss: 0.0690 - accuracy: 0.9830 - val_loss: 0.1022 - val_accuracy: 0.971
8
Epoch 16/25
32/32 [==============================] - 49s 2s/step - loss: 0.0751 - accuracy: 0.9785 - val_loss: 0.1027 - val_accuracy: 0.971
8
Epoch 17/25
32/32 [==============================] - 51s 2s/step - loss: 0.0770 - accuracy: 0.9770 - val_loss: 0.0930 - val_accuracy: 0.971
8
Epoch 18/25
32/32 [==============================] - 53s 2s/step - loss: 0.0564 - accuracy: 0.9873 - val_loss: 0.0902 - val_accuracy: 0.973
8
Epoch 19/25
32/32 [==============================] - 48s 2s/step - loss: 0.0540 - accuracy: 0.9883 - val_loss: 0.0976 - val_accuracy: 0.973
8
Epoch 20/25
32/32 [==============================] - 49s 2s/step - loss: 0.0748 - accuracy: 0.9790 - val_loss: 0.1067 - val_accuracy: 0.969
8
Epoch 21/25
32/32 [==============================] - 48s 2s/step - loss: 0.0780 - accuracy: 0.9790 - val_loss: 0.0974 - val_accuracy: 0.959
8
```

Dense Net

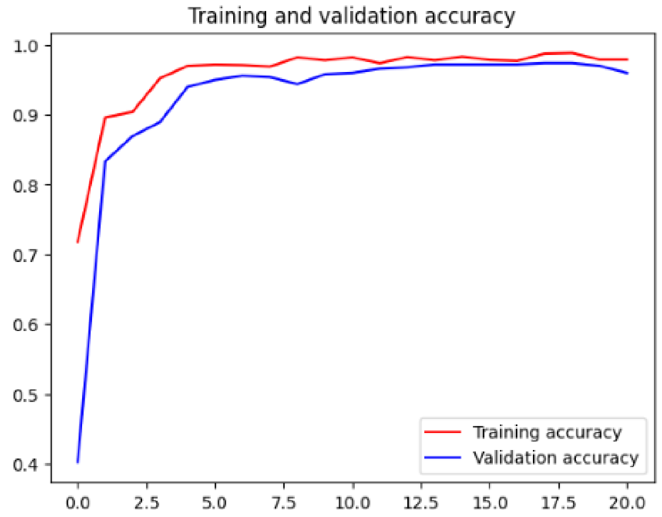
Pretrained Model

(train and validation accuracy visualization – load model - evaluation)

In [ ]:
```
import matplotlib.pyplot as plt
acc = dense_net_transfer_history.history['accuracy']
val_acc = dense_net_transfer_history.history['val_accuracy']
loss = dense_net_transfer_history.history['loss']
val_loss = dense_net_transfer_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)
```



In [ ]:
```
#model = tf.keras.models.load_model("dense.h5") # rollback to best model
dense_net_transfer.evaluate(val_data_multi)
```

```
16/16 [==============================] - 14s 837ms/step - loss: 0.0915 - accuracy: 0.9678
```

Out[18]:
```
[0.09147188812494278, 0.9678068161010742]
```

Dense Net

Pretrained Model

(read test data – make predictions – Save submission file)

In [ ]:
```
test_df = pd.read_csv("/kaggle/input/plant-pathology-2020-fgvc7/test.csv")
test_df['img_name'] = test_df['image_id'] + ".jpg"

test_datagen = ImageDataGenerator(rescale=1/255)

test_generator = test_datagen.flow_from_dataframe(dataframe=test_df,
                                                  directory="/kaggle/input/plant-pathology-2020-fgvc7/images/",
                                                  x_col="img_name",
                                                  y_col=None,
                                                  target_size=(256, 256),
                                                  class_mode=None,
                                                  batch_size=3,
                                                  shuffle=False,
                                                  seed=42)

test_generator.reset()
```

```
Found 1821 validated image filenames.
```

In [ ]:
```
preds = dense_net_transfer.predict_generator(test_generator, verbose=1, steps=607)

preds_df = pd.DataFrame(preds, columns=["healthy", "multiple_diseases", "rust", "scab"])

submission = pd.concat([test_df.image_id, preds_df], axis=1)
```

```
607/607 [==============================] - 46s 67ms/step
```

Out[20]:

	image_id	healthy	multiple_diseases	rust	scab
0	Test_0	0.000111	0.002933	0.996945	0.000011
1	Test_1	0.000018	0.001202	0.998775	0.000004
2	Test_2	0.177084	0.414771	0.087757	0.320388
3	Test_3	0.999806	0.000059	0.000040	0.000095
4	Test_4	0.000008	0.000232	0.999758	0.000002

In [ ]:
```
submission.to_csv("submission_DenseNet.csv", index=False)
```

Dense Net

Pretrained Model

(read test data – make predictions – Save submission file)

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```
test_df = pd.read_csv("/kaggle/input/plant-pathology-2020-fgvc7/test.csv")
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                                                  target_size=(256, 256),
                                                  class_mode=None,
                                                  batch_size=3,
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test_generator.reset()
```

```
Found 1821 validated image filenames.
```

In [ ]:
```
preds_df = pd.DataFrame(preds, columns=["healthy", "multiple_diseases", "rust", "scab"])

submission = pd.concat([test_df.image_id, preds_df], axis=1)

submission.head()
```

```
607/607 [==============================] - 46s 67ms/step
```

Out[20]:

	image_id	healthy	multiple_diseases	rust	scab
0	Test_0	0.000111	0.002933	0.996945	0.000011
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4	Test_4	0.000008	0.000232	0.999758	0.000002

In [ ]:
```
submission.to_csv("submission_DenseNet.csv", index=False)
```

In [ ]:
```
den_model = tf.keras.models.load_model("dense.h5") # rollback to best model
den_model.evaluate(val_data_multi)
```

```
16/16 [==============================] - 17s 826ms/step - loss: 0.0863 - accuracy: 0.9799
```

Out[23]:
```
[0.08627106249332428, 0.9798792600631714]
```

Made by

Karima Sobhi Haidy Ashraf Nada Abdallah

Thank You